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THE MINERAL SANCTION

THE
MINERAL SANCTION

AS AN AID TO

INTERNATIONAL SECURITY

BY

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"A retarding influence which in time may be considerable is the fact that no nation is really self-contained as to war supplies, and that with the vastly increasing demands of modern warfare, essential supplies in huge quantities must be obtained from all quarters of the globe, even by the nations most favored with domestic supplies. The problem of adequate preparation involves ways and means to keep these many channels open, which is probably beyond the power of the strongest nation. Realization of the appalling magnitude of the raw-material problem of preparedness may in time tend to delay hasty decisions to declare war."—Professor C. K. Leith, *World Minerals and World Politics*, New York, 1931, p. 149.

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THESIS

1. Article XVI of the League's Covenant has proved to be too comprehensive and too drastic to employ without danger of disastrous repercussions. It is important, therefore, to dissect this compound economic, financial, and military group of sanctions; so that appropriate parts of it may be defined for prompt use if necessary against a nation that is convicted by unanimous vote of the Assembly to be an aggressor within the meaning of Article XV.[1] Surely it is futile to possess an instrument that the member States of the League would never agree to use and faithfully to enforce. It is an ill-equipped workshop that has no hammer available but a steam-hammer, which the mechanics are afraid even to use.

2. A financial sanction, such as that implicitly contained in Article XVI, would naturally not be used except in extreme cases, because even the smallest of nations can hit back by defaulting on existing loans. Creditor nations would never agree among themselves to use a sanction of the sort.

3. For a nation that is not industrialised, an embargo on the supply of war munitions will generally be a sufficient menace; that is, one that will certainly be used if the aggressor refuses to submit its grievance to the International Court of Justice, or to the Council of the League of Nations.

4. In this discussion it is suggested that an agreement among the nations to refuse supplies of minerals (and

[1] The essential parts of appropriate Articles are reproduced for reference on p. 93.

therefore metals, raw or manufactured) to an " aggressor " would be a more suitable way to restrain an *industrialised* Power that " resorts to war," because :—

(*a*) no industrialised nation can carry on without a continuous and sufficient supply of minerals, which may be wanted in enormously increased quantities for war ; and

(*b*) no country is self-contained as regards natural mineral supplies, and these cannot be made artificially, or be replaced by substitutes ; they must be obtained from other countries.

5. The advantages of this so-called Mineral Sanction are therefore :—

(*a*) It is one that will not require revision for an indefinite future, for mechanisation will continue to extend with the development of technical science ; and, as the League of Nations is necessarily a slow-moving machine, this is important ;

(*b*) it can be used to " freeze out " any aggressive Great Power that relies on accumulated war stocks to seize territory, or otherwise to take advantage of the moral effect of a sudden attack on a weaker or unprepared nation, in order to wield the usually effective diplomatic weapon of a *fait accompli ;*

(*c*) it need not interfere with ordinary trade, food supplies or with general finance ; and therefore

(*d*) it is not too onerous for the weaker nations faithfully to observe.

6. A sanction that can be put into operation immediately, and is likely to be defeated only to an unimportant extent by smuggling, will be so obviously a menace that no refractory nation will run the risk of losing by war what might be obtained, if its cause be just, in the International Court of Justice. A menace of the

sort will thus, in general, seldom or never be used at all ; it is a police precaution, not a military measure.

7. To use the Mineral Sanction, like any other specified embargo which is implicitly contained in Article XVI, will require :—

(*a*) Authoritative definition by the League ; and then
(*b*) legislation in each country authorising its executive Government to act immediately in accordance with the unanimous vote of the Assembly of the League.

8. Conferences for disarmament can succeed only if they follow, not precede, agreement regarding practicable and simple sanctions that can be and will be promptly applied to appropriate nations. Without this prior agreement to exercise the control of essential raw materials, even agreed scales of disarmament between industrialised nations will be out of date, because of technical developments, before they receive legislative ratification. Agreements regarding so-called equality in scales of armaments cannot be discussed fairly, except in an atmosphere of security ; and security cannot be assured at present because there is no recognised schedule of appropriate sanctions that members of the League can impose in unison.

9. Without the United States, it would be useless, naturally, to employ Article XVI in its present form against any nation ; but there is nothing to prevent the United States from adopting the Mineral Sanction in unison with members of the League. This indeed would be consistent with the action of the United States in instituting the Kellogg-Briand Pact for all nations, and in joining other countries to impose an arms embargo against Bolivia and Paraguay.

10. The Mineral Sanction is not applicable to all forms of international disputes ; nor is any other specific

sanction. Like medicines, each form of sanction should be applied only to appropriate cases on the advice of technical specialists. Sanctions that are mutually antagonistic lose, when compounded, their value as deterrents. That is what is wrong with Article XVI.

PART I

ORIGIN AND NATURE OF THE SCHEME

It was General Smuts who first suggested the term "Mineral Sanction" when discussing the proposal which was made in my Presidential Address to the British Association in 1929. At that time the most practicable way to inaugurate a scheme of the sort seemed to be by agreement between the British Empire and the United States; for, between them, these two possess some two-thirds, and control three-fourths, of the world's reserves of economic minerals.

The scheme was discussed with more technical detail in the Trueman Wood lecture to the Royal Society of Arts on 29th January 1930[1]; and the essential facts then cited hold good to-day.

The Failure of Article XVI

It was pointed out in 1930 that if a situation arose that required the application of the economic and general boycott provided by Article XVI of the League's Covenant to any Great Power, the League's machinery would inevitably fail to function. This forecast was verified most conclusively when the aggressive action of Japan in Manchuria was condemned by the unanimous vote of the Assembly on

[1] *Journ. Roy. Soc. Arts*, vol. lxxviii., 14th February 1930. This lecture and the Presidential Address to the British Association, 1929, were reproduced as a pamphlet by the Carnegie Endowment for International Peace, No. 266, dated January 1931.

the 24th February 1933; for the members of the League that condemned Japan's action as illegal according to the Covenant, took no action of the sort explicitly prescribed, either "immediately" or later. What they did do, however, shows the futility of relying on a sanction that carries with it either no practicable form of restraint, or is one that is too drastic for imposition. They appointed, as an Advisory Committee, the representatives of twenty-two states, including, by special invitation, the United States; and this Committee, on 15th March 1933, formed "two sub-committees: one to examine the question of export of arms to the Far East, and the other to consider the practical implications of the non-recognition of 'Manchukuo.'" [1]

Japan knew quite well that the extreme action prescribed by Article XVI would never be attempted; and that the Japanese Government's representative at the League Assembly was himself conscious of this possible development was shown by his speech when the Lytton Commission's Report was under discussion in December 1932.[2] And then, whilst the new Advisory Committee was thinking of discussing [3] the steps that ought to be taken, Japan was vigorously acting; for on the day following the unanimous vote in the Assembly, the Japanese Army commenced a new offensive, invaded and occupied Jehol Province, extended their conquests south of the Great Wall, and after fifty days of fighting (during which, according to Mr Wellington Koo,[4] China suffered some 30,000

[1] *Survey of International Affairs for 1933*, published under the auspices of the Royal Institute of International Affairs, 1934, Part IV, Sect. IV, pp. 510, 511.

[2] *Ibid.*, p. 496.

[3] They did not meet until 15th March.

[4] *Survey of International Affairs for 1933*, p. 518.

casualties) forced China to sign a truce at Tangku on the 31st May 1933.

This truce, of course, superseded all resolutions of the League, which was again faced with a *fait accompli.* The League, for want of a suitable instrument of prompt action, had thus failed to prevent a war of aggression and has now no means of enforcing relinquishment of the territory which was severed from the control of the National Government of China in 1933.[1]

It is not necessary to discuss the merits of the dispute between Japan and China, which had been investigated on the spot by Lord Lytton's Commission, and was thoroughly discussed by the Council and Assembly of the League between November 1932 and February 1933. There is no doubt that it was a dispute that fairly came within the terms of the League's Covenant for settlement, and that Japan, in contending that the circumstances were special, was prepared to run the risk of an adverse vote. Article XVI thus proved to be an instrument of sanction wholly unsuitable to be used as a means of restraint ; it proved to be no real menace to a Great Power that found it convenient—as Japan did—to disregard the views of the rest of the League, and to invade the territory of a weaker neighbour.

It is this last point that is fundamentally important, for any penal law must necessarily fail if the criminal knows that its minimum penalty is too severe to be

[1] " That which could have been nipped in the bud by a few firm actions in September 1931, was left to drift until it would have required sanctions to arrest it in 1933 ; and that which can still be stopped by sanctions to-day will be neglected to develop into a first-class war."—C. C. Wang, " The Pan-Asiatic Doctrine of Japan," *Foreign Affairs,* New York, October 1934, p. 67.

administered or too difficult to carry out: if sheep-stealing were still a capital offence, no jury would convict an offender. But in this case the so-called "moral sanction" of the Kellogg-Briand Pact of Paris[1] broke down, too; for Japan had signed that Pact as well as the League Covenant and the Nine-Power Treaty of Washington.[2]

Necessity of Simple Sanctions

The proposition then before us is to formulate some restraining sanction which can be, and will be, put into force "immediately"—a sanction that will be to the pact-breaker so obviously a practicable menace that it will seldom, if ever, be put into force at all. The object clearly is to prevent an initial act of war, and, instead, to enforce judicial settlements of international disputes by reference to the Council and Assembly of the League or to the Court of International Justice according to the terms of the Treaty.

It was in the hope of finding some such simple but sufficiently effective measure that the Mineral Sanction was suggested in 1929 and more precisely explained in 1930. Its suitability as a directive

[1] A solemn declaration "in the names of their respective peoples, that they condemn recourse to war for the solution of international controversies and renounce it as an instrument of national policy in their relations with one another . . . that the settlement or solution of all disputes or conflicts, of whatever nature or of whatever origin they may be, which may arise among them, shall never be sought except by pacific means."—(Signed at Paris, 27th August 1928; came into force 24th July 1929.)

[2] An agreement (1921-22) to respect the sovereignty, the independence and the territorial and administrative integrity of China, with the principle of equal opportunity for commerce and industry of all nations.

measure ought now to be examined technically on behalf of the League ; it is not inconsistent with the principle of intervention already adopted as Article XVI, but is in fact only a part of the too comprehensive and drastic economic sanctions. It is a part of it that apparently can be used promptly and effectively, without a general upset of the financial relationships between the nations ; and it can be used not only to prevent a threatened war, but to restore the *status quo* when any sudden aggressive action takes the form of territorial invasion.

Thus, the institution of a Mineral Sanction requires no revision of the Covenant ; it would take the form of a separate and supplementary agreement exactly of the kind which was proposed by the Chaco Commission for an embargo on the export of arms and war munitions to Bolivia and Paraguay. And the action taken in this case indicates that the imposition of an embargo on the export of mineral products would not be illegal according to the Covenant ; for when Bolivia attempted to forestall the proposed embargo on the supply of munitions by appealing to the League in accordance with Article XV, the legal advisers of the League decided that, as the embargo would be a separate and independent measure taken by Governments in their individual capacity and not by the Council of the League as a body, the invocation of Article XV did not affect the situation.[1] The Government of Great Britain, having already authority to act without further reference to Parliament, took the initiative, others followed ; and the embargo was ultimately enforced by twenty-eight arms-exporting countries. In the same way, power to apply the

[1] *Survey of International Affairs for 1933*, p. 434, footnote.

Mineral Sanction could be given to other Governments by their respective legislative bodies.

The Mineral Sanction could be adopted by those States that are without as well as within the League, just as the Kellogg-Briand pact was adopted by some sixty nations. It would be used only against an industrialised nation that is convicted by unanimous vote of the Assembly, according to Article XV of the Covenant, to be the aggressor; its use therefore should be decided normally after obtaining the opinion of an authoritative body of technical specialists.

The Bases of the Mineral Sanction

It is assumed in this discussion that a surprise attack by one first-rate Power on another will seldom or never be final and decisive within a short period. This question, about which there are differences of opinion, is discussed on subsequent pages (pp. 28, 29).

The deterrent value of the Mineral Sanction is then based on the following simple considerations :—

(1) The recently increased, now almost complete, mechanisation of all forms of armaments on land, sea and air, makes all Powers absolutely dependent on a supply of mineral products (including metals, of course) wide enough in variety for the production of the essential alloys, and with relative certainty of obtaining continuous supplies in sufficient quantities for war purposes; that is, in the case of an industrialised nation, anything from five to twenty times its peace-time requirements.

(2) No country in the world, not even the United States, can produce, from its own natural resources, the variety and quantity of minerals so needed, even

for peace-time industrial requirements ; nor will any country ever be able to do so ; for minerals, unlike vegetable products, cannot be transplanted, cannot be reproduced synthetically and cannot be replaced by artificial substitutes.

(3) No blockading force would be required to impose this sanction ; the nations in the pact—those for example who might form a jury of the kind that condemned Japan in February 1933—would merely refuse to give " port-clearance " for minerals and metals to be consigned to the pact-breakers ; the old dangers due to disregarding the " freedom of the seas " would not arise ; and no international force like that proposed in Article XVI would be necessary.

(4) Indeterminate questions of what is contraband or conditional contraband would not then occur ; for no interference with trade in food supplies, clothing for the civil population, or medical supplies, would follow the refusal to supply minerals and metals in quantities that are obviously useful for armaments and war munitions.

(5) Financial disturbances—with aftermaths of the kind that we now suffer from—would not occur ; for the country that is subjected to the Mineral Sanction would be compelled, when the war-clouds pass away, to repair its stocks again by purchase from the country that has surplus supplies for sale. Profiteers and financiers would thus have relatively small chance of putting effective pressure on their Governments to be unfaithful to the pact ; for it is the financially weak Governments that are always the danger to all such international agreements ; fear of the financial effect alone of the full economic sanctions would make most

nations hesitate to put Article XVI into force against any Power, great or small.

(6) In case of sudden invasion by a strong nation on one that is unprepared, the suggested Mineral Sanction has another important advantage over Article XVI in its crude form; for the decision to withhold mineral supplies can be continued afterwards if necessary to freeze out the nation which has used its aggressive armaments for a sudden raid of territorial conquest, or for the purpose of producing a moral effect and the dictation of a disastrous truce to the defenceless nation. The adoption of any such measure as the Mineral Sanction would thus produce that feeling of security which is necessary to prepare the way for disarmament, especially as regards aggressive instruments of war.

It will be noticed that rubber and other substances of an organic chemical nature have not been included in this form of sanction. This is because :—

(*a*) Unless specific materials are named, ordinary trade would be interrupted, and supplies for the civil population would be cut off, thus tempting "weak" nations to break the pact; and

(*b*) many organic materials can be manufactured synthetically to supplement, sometimes to replace, stocks; and, with the development of science, progress in this direction is certain, whilst mineral raw materials will never be obtained except from those natural sources which are fixed. It is important to have one sanction which is relatively permanent in value as well as simple in definition to permit of prompt control by an embargo on exports.

Development of Armament "Materials"

Very little supplementary explanation seems to be necessary for a proposition which is so simple. But it is evident from the recent disarmament discussions that very few of those who influence our political commitments have the slightest conception of the enormous strides which have been made in recent years in, for example, the utilisation of ferro-alloys. Just before the War, as a member of Lord Fisher's Commission on Navy Fuel and Engines, I learned that it was then dangerous to rely on internal combustion engines with cylinders much over 500 horse-power. Now cylinders of over 1000 horse-power, with a generous factor of safety, are quite common in the mercantile marine; and the change is due entirely to recent metallurgical advances which have permitted new designs. This is but one illustration; and still the use of metals, especially new alloys, is developing without visible limit to its possibilities. We have indeed to recast fundamentally our mental estimates of what is necessary for war; we have to realise that mechanisation—and therefore the use of a wide range of mineral products—requires a complete change of our estimates of speed and power, as well as of material, in problems of tactics and strategy.

Our General Staffs have doubtless worked out new plans based on the possession of what they regard as improved "materials"; that is, to them, weapons —naval, military and aeronautic. But discussions, which have dragged on without result through the Disarmament Conference during the last two years, seem to have overlooked the fact that the so-called "material" of armaments is made from mineral raw

materials, and that they cannot be manufactured by any country.

Reliance on Substitutes

Attention has been drawn to the fact that minerals cannot in general be replaced by artificial substitutes : that fact the ordinary man-in-the-street knows quite well ; but he might be surprised to learn that, only with a serious loss of efficiency, can one metal be used to replace another in technical industries. One might go further and show that, with the same metal, even a change from smelting methods that suit peace-time requirements to others that are specially wanted for war munitions, may result in serious or fatal embarrassment to a belligerent.

No better illustration could be chosen than that of the iron and steel industry of Great Britain to show the kind of embarrassment that might thus occur to any nation which is suddenly subjected to the Mineral Sanction. Before the outbreak of War in 1914, probably no one—certainly not the War Office—ever thought for a moment that Great Britain might be unable to meet all war requirements in steel ; it was a product for which Great Britain had justified the reputation of being the leader for quality ; and it was the third producer for quantity.

Yet, only five or six steel-making firms in the country had had any experience up till then of the manufacture of shell steel, and the others could not, at short notice, comply with the specification laid down by the War Office as obligatory. By October 1915 it was found necessary to make substantial changes in the specifications for shell steel in order that the firms might do more to meet the increased

demands ; and yet, even then, early in 1916, supplementary supplies had to be obtained from America.[1] How many lives were lost because of this delay in meeting the urgent demands for shell steel ? What would the situation of Great Britain have been like if she were then fighting alone and unable to obtain supplies from neutrals ?

That, however, is not the whole story ; for whilst Great Britain had abundant reserves of phosphoric iron-ore, and could turn out an annual total of 15 million tons, it was not possible to produce more than $1\frac{3}{4}$ million tons of the special hematite iron-ore which was wanted for the production of the shell steel demanded by the War Office in 1914-15. Nor could the output of iron-ore of all sorts in the country be increased at once to meet the full demands ; for throughout the whole War period, the foreign ore imported annually was well over 6 million tons. What would have happened if Great Britain could not have obtained that ore from abroad—two-thirds of it being from one country alone, Spain ? Fortunately, Spain remained neutral and supplied, not only $4\frac{1}{2}$ million tons of iron-ore annually, but large quantities of pyrites (wanted for the manufacture of sulphuric acid) as well as copper and lead.

Another unforeseen embarrassment in connection with the steel industry in Great Britain arose on the outbreak of War on account of the cutting off of supplies of Austrian magnesite bricks, which were used for lining basic-steel furnaces. " Prior to the outbreak of War, the magnesite-brick industry was almost wholly in the hands of the Austrians, who not

[1] F. H. Hatch. *Record of the work of the Iron and Steel Production Department of the Ministry of Munitions*, 1919, pp. 8-10.

only possessed in their own country extensive deposits peculiarly suited for brick-making, but had devoted both skill and money to the perfecting of their products, with the result that they commanded practically the entire custom of the steel trade in this country. One, or two at the most, of the British manufacturers had made small quantities of bricks from magnesite imported from Greece, but with small success." [1]

Thus, on the outbreak of War, Great Britain had suddenly to find new sources for magnesite and had to learn to make suitable furnace bricks. The only large source of the mineral, relatively near, was Greece, where the political position was uncertain during the early part of the War. But supplies were obtained from the island of Euboea, where the loading of vessels had to be carried on under armed forces provided by the Navy.

All these difficulties were eventually overcome, but only after delays and at a cost of lives at the Front that cannot be estimated. What would the situation have been like but for the chance of obtaining supplies of magnesite from one neutral nation, accessory supplies of ore from another, and supplementary shell steel from another? In 1915 Great Britain produced only 145,900 tons of shell steel; in 1917 the output was 1¼ million tons. How would the military situation have been affected if the larger quantities had been available in 1914 and 1915?

This is but one of many illustrations that might be chosen to show that even a country well equipped with ore, fuel, flux and smelting capacity could be embarrassed if cut off from outside supplies of one or other of the accessory raw materials. And that

[1] F. H. Hatch, *op. cit.*, p. 110.

illustration is chosen from Great Britain's second strongest mineral industry. For supplies of copper, lead, zinc and other essential metals and minerals, the country is almost entirely dependent on outside sources, most but not all of which fortunately can be obtained from parts of the British Empire around the Atlantic, and could be utilised so long as the Navy is able to keep communications open.

It is plain from this illustration that no nation could possibly stand alone as an aggressor if subjected to the Mineral Sanction. It is useless to have a surplus of one mineral if there is a deficiency of another : each mineral has its own special function, and failure to obtain supplies of any one mineral may prove to be a fatally weak link in the chain of industries required for armament manufacture. The experiences of Great Britain during the War show that even to change from one variety of steel to another may result in delays and loss of efficiency sufficient possibly to reverse the fortunes of war.

Reliance on Preparatory War Stocks

The precautionary accumulation of mineral stocks is occasionally cited by critics as one way of making up for deficiencies in a country's own natural supplies. The unreliability of any schemes of the sort was anticipated and discussed in the Trueman Wood lecture in 1930. Obviously no sane nation would go to war if it could not hope to continue it indefinitely ; and the dependence on stocks is always known to nations that have mineral intelligence departments. Apart from the enormous capital outlay required for the accumulation of sufficient war stocks, their existence

would be a continual menace to the commercial community, as the surplus stocks might have to be released on to the markets whenever technical advances put some of them out of date.

Professor C. K. Leith [1] has published a diagram showing the sudden rise in 1914 of German import figures for some substances of munitions' importance. Commenting on these figures, he says (p. 142) :— "At the time these figures were not generally known, but interpretation of the figures in the light of what happened shows how clearly they pointed to danger ahead. In the first six months of 1914 Germany accumulated stocks of manganese, brass, nickel, tin, aluminium, asbestos, sulphur, graphite and mica so far in excess of previous rates as to show beyond question that some extraordinary use was planned."

Soon after the War started the Germans were able to extend their own resources by rapidly seizing the valuable mineral fields of north-east France and the metallurgical resources of Belgium ; they had then also the additional resources of Austria, Hungary, and, soon after, those of Serbia, Bulgaria and Turkey ; they also utilised what was left of the petroleum fields of Roumania ; and they imported considerable but unknown quantities of minerals from and through the neutral Scandinavian countries and Holland. But they nevertheless collapsed mainly for want of mineral supplies ; even failure to obtain phosphatic mineral fertilisers, which were formerly imported, resulted in a serious diminution of agricultural food supplies in Germany. Essential civil requirements as well as war munitions must be met, or the population will refuse to support the continuance of a war. The

[1] *World Minerals and World Politics*, New York, 1931, p. 143.

nation that relies on mineral stocks in war-time will just be heading for irreparable disaster.

A committee of well-known mineral specialists reported in 1925 to the Institutes of Mining and Metallurgical Engineers in New York regarding the mineral policy of the United States. Special studies of a selected number of minerals led sub-committees to recommend the accumulation of stocks to meet a possible war emergency; these varied from six to twelve months' estimated consumption for some minerals for which the United States industries depend mainly or wholly on foreign sources of supply.[1]

Another conference held in 1933, in which other specialists took part, issued a group of papers in July of that year, and one of them (contributed anonymously, presumably by someone in an official position), advocated the accumulation of war-insurance stocks as part payment of the debt to the United States. The substances selected for acceptance in this way were: manganese-ore, chrome-ore, mercury, mica, tin, nickel, rubber, tungsten-ore, cobalt, radium, coconut shells. This plan, it is argued, would be one way of removing the depression through over-production of raw materials. "The presence of these materials in possession of the Government would create a feeling of greater security in the minds of those responsible for the national planning, and would be a real guarantee towards peace, in that the nations of the world would know that we had repaired many of the weak spots in our national deficiencies of industrial raw materials.

"In that these stocks would be held under the jurisdiction of the Government, to be used only in

[1] *International Control of Minerals*, New York, 1930.

case of national emergency, they could have no effect on normal trade." [1]

The first argument is a variety of the usual one of "prepare for war to ensure peace," and the second shows faith in the continuity of Government policy. Recent history shows that the sedative effect of these two drugs is not lasting. The formation of stocks on a relatively small scale may help a nation to tide over the critical period of a sudden attack, but a sane nation will not go to war as an aggressor without fair certainty of obtaining continuous supplies for an indefinite period.

An article published in the *Echo des Mines* for 20th April 1935, suggests the accumulation of stocks of antimony, copper, lead, nickel, tin and zinc as metals of more war value to France than her hoarded gold. Alternatively, without disturbing the gold hoard, it is suggested that industrial concerns might be subsidised to hold heavy stocks of metals which are required for war. Like all other proposals for acquiring preparatory stocks, these ingenious proposals hold good only for short wars, and incur the same commercial objections.

The Effect of Surprise Attacks

Everyone will be familiar with the considerable amount of discussion recently carried on about the possibilities of large-scale and sudden air attacks on an unprepared nation. Whether such attacks will be sufficient to dominate a first-class Power in a short time to such an extent that it will submit to the terms of the aggressor must be a matter of doubt. What, however, is evident, is that no potential aggressor

[1] *Elements of a National Mineral Policy*, New York, 1933, pp. 148-154.

would be so reckless as to trust entirely to bringing off a quick decision by any such sudden attack, without also taking into account the possibility of its developing into a protracted struggle. Pacts of the so-called "Air Locarno" type will certainly form a grave deterrent to a nation that would otherwise gamble on the success of sudden air attacks only.

Another deterrent must naturally be the fact that a large-scale air attack on the enemy's national life is a method of making war which hitherto has been untested and therefore in itself incurs unknown risks of failure. In hoping for a quick decision in 1914, the Germans were at least relying on the application of perfected machinery and matured plans for making war by well-tried methods; and yet their attempt failed. It must be accepted, therefore, that an intending aggressor in making his preparations will contemplate a possibly protracted struggle; and an essential condition for the maintenance of any such struggle is a large and continuous supply of minerals, much of which must necessarily come from foreign sources, since no country is self-contained in minerals. So, whatever views may be taken regarding the possibility of securing success by surprise attacks, the likelihood of the Mineral Sanction being applied must at least be a deterrent to a potential aggressor. That it should be an additional deterrent is the fundamental test of the value of any workable sanction that can be, and therefore will be, applied immediately by collective action among the nations.

Alternative Forms of Agreement

Instead of considering the control of mineral raw materials, the nations have been active during the

last few years along three main lines in the search for security against war. They have attempted to establish :—

(1) Agreed scales of disarmament ;
(2) embargoes on the export of war munitions to belligerents ; and
(3) new groups of alliances and ententes.

The Mineral Sanction is not intended to replace any of these lines of action. On the contrary, it is intended, by producing a feeling of relative security, to prepare the atmosphere for their consideration in ways that offer a greater hope of success than has so far been possible ; for no one can say that these well-meaning efforts have been successful.

Disarmament Agreements

As to the first of these alternatives, it is obvious that, without some agreed factor for a nation's responsibilities in areas outside its own home territory, nothing approaching parity in naval or military armament—qualitative and/or quantitative—can ever be possible. And even if the nations ever reached in conference an agreed formula, research in technical science would put any agreement of the sort out of date before it could be ratified by the various legislative bodies. Within some limits—for example, in the construction of capital ships—each industrialised nation could, and, with a war scare, would quickly be in a position to repeat and even exceed the horrors of 1914-18.

The only substantial results that have been obtained so far from the discussions of the Disarmament Commission since its opening session on 2nd February

1932 have been the determination of Germany, in October 1933, to leave the League of Nations, and the denouncement by Japan of the Washington Naval Treaty at the end of December 1934. Japan, from the beginning of the discussions at Geneva, objected to supervision of armaments, and now discovers that she has special need of parity with the other two principal Naval Powers.

But, above all special considerations of a kind that cannot be fairly equated, the necessity of obtaining some form of reliable security before disarmament has been the chief obstacle to agreement. And it is just here that some such form of restraint as the Mineral Sanction is wanted. If the Mineral Sanction could be first established, there would be produced an atmosphere of relative security which would make disarmament conferences less a display of nerves and mutual suspicions. With the Mineral Sanction ready for immediate imposition, it would be realised that the quantitative problem would be of less importance, and there would be left then the problem of reducing or abolishing the aggressive type of armaments that can be used for sudden invasion in the hope of securing a quick and decisive result. Even this type of armament loses much of its importance when it is known that the Mineral Sanction can be used still as a peaceable means of reversing the *fait accompli*, which, under existing conditions of international relationships, must always be the diplomat's most formidable weapon. The greater a nation's scale of armaments, the greater is its dependence on the mineral resources of other countries.

In a later section it will be shown that Germany could not hope for success in attacking France if

France were free to import munitions, whilst Germany could not purchase minerals from the outside world. The other nations need do no more than refuse to sell minerals to the country which is declared by the League Council to be the aggressor ; it would not be necessary for them to declare war, or to commit any warlike act, for France would be free to import her requirements by sea. Equally, and in the same way, France would fail if she attacked Germany without the approval of the League. Neither country could blockade the other.

Embargo on the Supply of Arms

We have witnessed two attempts during the last two years to influence warlike activities by embargoes on the supplies of arms and war munitions : one when Japan was pushing her conquests in Manchuria in 1933, and one in connection with the Bolivia-Paraguay war. The second I have already referred to as in operation till recently by twenty-eight of the arms-exporting nations. It was up to January 1935 an embargo applicable to both belligerents and therefore of little value, for history shows that atrocities are as likely to be committed without, as with, the modern type of arms. This embargo also illustrates the difficulty of moving the international machinery along common-sense lines ; exporters could not send arms to the belligerents, but were free to send the accessory machinery necessary to move an army in the field ; such accessories are equally, in the circumstances, munitions of war.

The prohibition in 1933 of the export of arms to both China and Japan was attempted by Great Britain alone, and the method adopted makes one

wonder if those who control our political activities are always sanely advised. Although the Foreign Secretary realised, when questioned in the House of Commons on the 21st February 1933, that action by one nation alone would be futile, a prohibition order was nevertheless issued on the 28th forbidding the export of arms to both China and Japan. The Government's action was naturally ill-received in China and did no harm to Japan, where armament factories are well equipped ; and, as no other country followed the example of Great Britain, the embargo was lifted on the 14th March. So long as the essential raw materials can be obtained, an embargo on the supply of arms will not effectively discourage the warlike intentions of an industrialised nation. Apologists for the action of the British Government described this isolated embargo as a gesture ; it would have been more accurately termed a grimace—a grimace that annoyed China and amused Japan. It merely demonstrated our impotence under present conditions to interfere with warlike acts except by war, when one of the parties is already equipped with armament factories and is generally industrialised.

In this case British ships were not allowed to take arms to Japan, but could load up with the materials that Japan wanted to feed her armament factories. The total effect of the double embargo was the reverse of that which was intended, for it could injure China only, China being the one that wanted arms but could not make them.

"*Locarno*" *Pacts*

Every attempt at the development of pacts between geographically related nations may serve in some

degree to postpone war; but we have recently had examples enough to show that there is a moral elastic limit to most nations, and, when self-interest seems to be in danger, pacts of collective security may prove to be as unreliable as treaties have been hitherto. Some pacts, too, are obviously one-sided bargains for nations like Great Britain. We might be able to help one continental nation to resist an aggressive neighbour on the same continent; but could any of them be of the slightest help to Great Britain if, say, Japan wished to take Hong Kong? All nations, however, could help to preserve the peace by refusing help—help in the form of essential supplies. So long as the nations will suffer no more than a temporary loss of a limited form of trade, they might be counted on to observe any such treaty faithfully, but recent history shows that most of them cannot be relied on to go further than this.

The institution of local defensive pacts, however, is the only practicable way to make use of the last desperate clause of Article XVI, namely, the use of an international force. Proposals, like the maintenance of a standing international air control, or of other branches of an international force, are quite out of the question in the present state of the world. What would happen, for example, if a mixed international force were sent to prevent Japan from invading any part of China? What would happen, indeed, if a flock of ducks were sent to turn a fox out of the fowl yard? On the other hand, if the other nations had in 1933 refused to supply Japan with mineral products, her warlike as well as industrial activities would have been paralysed: she would have been compelled to think twice before going to war.

Air pacts of suitable geographical range, like that recently arranged between Great Britain and France, offer an insurance against sudden and destructive attacks on thickly populated or industrialised areas, and so add to the feeling of security. They are necessary in consequence of the wider and more rapid range of air activity which has developed since the War; but any participants in a pact of the sort must accept the fact that in going to the defence of an attacked nation they declare war against the aggressor, and must be prepared to use other arms as well. The Mineral Sanction is for use by the nations that take no part in meeting air raids, or otherwise commit no act of war.

Mineral Sanction for War Conditions Only

After the German Government had announced, in October 1933, their intention to take no further part in the Disarmament Conference and to leave the League of Nations, communications appeared in some journals calling attention to a supposed increase in the importation of nickel into Germany, some writers even suggesting the immediate application of the Mineral Sanction. This most definitely is no part of my scheme; and its application to any nation in time of peace would be fundamentally opposed to the spirit of the proposal.

There is nothing in the Covenant of the League which would justify the imposition of restraint on any nation which imports raw material that might be turned afterwards to use in war. No authority could possibly estimate the industrial requirements of any country; and any attempts to impose limits of the sort in any form, even if suspicion of "intent to commit

a felony" be well grounded, would merely precipitate a war and provide a reasonable justification for it too. No group of nations would ever agree to a system of rationing imports during peace-time; and impracticable proposals of the sort have no possible relation to the Mineral Sanction, which is proposed for imposition, if necessary, only on a nation that actually undertakes war contrary to the stipulations of Articles XI-XV of the Covenant.

In the case of Germany, the question is not worth serious discussion; few countries are now more dependent on minerals from outside, and no other country has had a more severe reminder of the futility of relying on stocks; for Germany, with wider alliances in 1913-14 than she has now, imported then abnormal quantities of those minerals that are essential for the manufacture of war munitions.

It is true that the British Empire and the United States in alliance could provide from their combined natural resources practically the full list of minerals required to maintain war activities indefinitely; but, knowing the composition of their peoples, and the form of democratic control under which their various Governments exist, one can be quite sure that if these two in alliance ever declare war on a nation it will be for the purpose of preventing that nation's aggressive activity. Great Britain is now no longer in the position that she held before the Imperial Conference of 1930. She cannot count now on the support of the Dominions in any war of aggression, but could be certain of their support if attacked. By its new constitution as a commonwealth of free nations, the British Empire is as incapable of attack as it would be secure in its natural resources for defence.

The Position of Neutrals

It is obvious that the formation, since the War, of a League of Nations alters fundamentally the position of so-called neutrals. During the War of 1914-18, neutrals were more useful to the Central Powers than their allies in supplying the essential raw materials. The Allies could provide material from their own resources only, but those neutrals that were suitably situated geographically could not only supply to the Central Powers minerals from their own deposits; they could be, and were, channels for the transmission of minerals from a wider world outside. Without supplementary supplies of copper, nickel and other minerals, obtained from or through neutral countries like those of Scandinavia, Germany could never have lasted till 1918.

If, however, any nations join the aggressor, they become equally liable to the effects of a boycott, with corresponding damage to their own industries. The Covenant of the League provides for no neutrals; and, at the time of its institution, it was assumed that all the allied nations would join the League. The only nation still outside that could seriously endanger the successful operation of the Mineral Sanction is the United States; but the Briand-Kellogg Pact of Paris enables America to join in a boycott of non-supply to an aggressor; it is indeed nearly a moral obligation to do so, and the object of this scheme is to enable all nations to join a mineral pact as an independent proposition without necessarily endorsing the Covenants of the League.

PART II

MINERAL RESOURCES OF THE PRINCIPAL POWERS

INDUSTRIALISED countries have been so well explored by mineral specialists that there is practically no possibility of a discovery being made in future which will upset the assumption on which the Mineral Sanction is founded, namely, that no country is or ever will be self-contained with regard to essential mineral supplies. There is still room for some surprise discoveries to be made in Africa, China, Canada, possibly even in the United States ; but they are not likely to close many of the existing gaps in the lists of their mineral resources. Qualitatively one can say that this is not likely ; quantitatively, one can say with certainty that no country, not even the United States, will ever be able to rely entirely on its own mineral resources.

The distribution of those minerals which have determined the present configuration of industrialisation is such that, even if China and Japan formed one national unit, it would never approach the resources of the United States, where most of the minerals that are used on a large scale in industries occur in sufficient quantities, especially petroleum, coal and ores of such metals as copper, iron, lead and zinc.

It is not easy to form an exact estimate of the resources of Russian territory, but it is almost certain that it is nowhere comparable to the United States

or variety and quantity of mineral deposits. Apart from the evidence of Russian external trade figures, showing considerable imports of necessary materials, there is a significant general distribution of mineral deposits which indicates an unusual concentration on the lands which border the Northern Atlantic, and a definite falling off in the value of ore deposits eastward of France and Western Germany. Professor C. K. Leith [1] has called attention to this peculiarity in the distribution of mineral deposits; and recent exploratory work in China shows by repeated negative results that the relative barrenness of Eastern Europe persists through Asia, and must always put a limit to the industrial expansion as well as, consequently, of military power among Eastern nations.[2]

In this Part a review of the mineral resources of the principal Powers is based on a consideration of their normal industrial activities. There is no certain way of obtaining a precise quantitative estimate of the total resources of any country, beyond general opinions regarding the probable trend of development in the near future. And such opinions are of value only as guides to policy; they do not help the Government that may be called upon suddenly to meet the requirements of an army on a war footing.

The only way of estimating what the military effect would be of imposing a Mineral Sanction on a country is to take the figures for domestic production, exports and imports, in order to obtain a first approximate figure for normal consumption. When war

[1] *World Minerals and World Politics*, New York, 1931, Chapter III.

[2] See H. Foster Bain: *Ores and Industry in the Far East*, New York, 1927. See especially the summary of conclusions given by E. F. Gay as a Preface.

breaks out there is no time to open up and work undeveloped mineral deposits ; a nation at war can rely only on what is immediately available in the way of mines and smelting facilities. Painful experiences in the Great War showed how very difficult it is, at short notice, either to raise additional supplies from low-grade deposits, or to switch over from civil industries to those required for armament manufacture ; and, unless a country can rely with certainty on a ready supply of minerals of standard quality, the loss of efficiency, especially of lethal munitions, may be fatal. There will always be unforeseen gaps in the pre-war estimates of any nation, no matter how well equipped it may be with a mineral intelligence staff. Indeed the first result of the work of any well-equipped intelligence staff will be to utter a warning that war is an impossible risk for any nation to undertake alone, against any other nation that is free to draw supplies from the rest of the world.

Reference to the discussion of substitutes given on p. 22 will show how difficult it is, even with a well-established industry, like that of iron and steel in Great Britain, to switch over to war requirements, without freedom to obtain, promptly and in quantity, war munitions from allied or neutral countries. By its nature, the Mineral Sanction rules out help from neutrals.

In the succeeding sections, figures are given to show to what extent the principal Powers now rely on their own mineral resources. In those instances in which imports largely exceed domestic production, it is evident that the country would not be able readily to meet from its own resources its requirements when on a war footing. In other instances, an isolated

nation might temporarily increase the output of its own low-grade domestic ores; but in every case it will be seen that, except for the United States and the British Empire taken as one unit, every nation shows large and serious deficiencies, and under war conditions could not long survive on its own resources alone.

The countries reviewed are, in order, the United States, the British Empire, France, Germany, Italy, Japan and Russia. Wherever there is a possibility of extending a country's resources by sudden seizure of neighbouring areas, these have been indicated so far as any such trespass seems to offer reasonable chance of temporary success. The minerals considered are those which are most definitely required as essential for war operations; and the statements made have no relation to the economic question of whether the minerals can be raised profitably for export or home consumption. The minerals specially considered are aluminium, antimony, chromium, copper, graphite, iron and steel, lead, magnesite, manganese, mica, nickel, platinum, quicksilver, sulphur, tin, tungsten and zinc. Nitrates are not included in this list because in an industrialised country they can be obtained if necessary by artificial means from the air; and fertilisers like phosphates and potash are wanted only in cases of prolonged isolation. It would be embarrassing, under war conditions, to run short of any of the others.

United States

As a single country, that forming the United States is better off than any other in resources o minerals that are required for munitions manufacture.

Yet, according to Professor C. K. Leith,[1] "notwithstanding its highly favoured position, the United States depends almost entirely on foreign sources for several important minerals: antimony, chromite, manganese, nickel, tin, asbestos, bauxite, nitrates, platinum and potash, and it is very largely dependent on foreign sources also for mercury, tungsten, barite, china clay, fluorspar, graphite, magnesite, mica and pyrite."

In this estimate, however, Professor Leith has in mind the needs of America for the maintenance of her established industries; but, as a nation is able, for some time during war, to divert some ordinary civil supplies to military use, it is necessary to curtail this list by cutting out the second "largely dependent" group, as well as asbestos, bauxite and potash in the first list, because sufficient supplies of them from domestic sources can be obtained temporarily, whilst nitrates can be made artificially. The deficiency would be serious then only with regard to the first five, namely, antimony, chromite, manganese, nickel and tin; the want of these might be serious, but hardly fatal, to American measures for defence against attack from any other Power.

Great Britain

The British Empire as a whole is better off than the United States for variety of essential minerals, but is not in all cases self-contained quantitatively; and this question cannot be considered without regard to the qualifying condition of requiring uninterrupted freedom at sea to assemble all the requisite necessary materials from its geographically scattered parts.

[1] *World Minerals and World Politics*, New York, 1931, pp. 49, 50.

By comparing the figures for production and external trade, assuming freedom to assemble minerals in Great Britain—which is its principal industrial area—from all other parts, one can form a first rough idea of the degree of self-sufficiency which the British Empire would enjoy. The figures for about 1928 and 1929, that is, before the depression resulted in an artificial restriction of output, give the best general guide to a first unqualified inference for each important mineral. The minerals of direct use in war are naturally only those to be considered ; the fact that the British Empire produces three-quarters of the world's output of gold and diamonds does not affect the question ; nor does the excess of production in one mineral compensate for the absence of another that is essential. The following general statements for each mineral show that there are some weak spots in the picture, some links weak enough to make the chain unreliable if the British Empire were limited absolutely to its own resources.

Aluminium.—The only area that can be relied on for sufficient bauxite is British Guiana, where it is possible to expand the ordinary production, which reached 216,652 tons in 1929.[1] From this bauxite, it would be possible to obtain 30,000 to 40,000 tons of aluminium in Canada and 10,000 to 15,000 tons in Great Britain, without increasing the present smelting capacities of these two countries. The metal retained to meet Great Britain's annual requirements amounts to about 30,000 tons. Thus, with uninterrupted means for assembly, our resources in aluminium ore and our smelting capacity round the Atlantic are

[1] There are undeveloped deposits of bauxite in the Gold Coast Colony also.

sufficient to meet considerably increased demands when necessary.

Antimony.—The normal annual requirement of Great Britain is of the order of 3000 to 4000 tons, but the output of the whole Empire does not exceed one hundred tons; and we are thus, like the United States, quite dependent on foreign sources—Mexico and Bolivia being the nearest, should South China, which is far the most important, be barred to us.

"*Asbestos*" is produced in the form of chrysolite in Canada on a scale well beyond the possible requirements of Great Britain. South Africa, including Southern Rhodesia, also produces more than we consume annually. For supplies of this mineral from Empire sources there need be no anxiety: the consumption of asbestos in Great Britain was about 34,000 tons in 1928, when Canada produced over 240,000, Southern Rhodesia 36,000, and the Union of South Africa 24,000 tons.

Chrome-ore is imported into Great Britain in quantities that vary around 25,000 tons annually, and many times this quantity can be obtained from South Africa, where the annual output of Southern Rhodesia has been well over 200,000 tons, in addition to 30,000 to 50,000 tons from the Union. India produces 45,000 to 50,000 tons of chrome-ore annually; but none is raised in the United Kingdom, and only small quantities in Canada and Australia.

Coal and its by-products can be raised within Great Britain in any quantity required.

Cobalt is coming into use for special steels, and may yet become important in the near future; but all that is likely to be required can be raised in Canada, which till recently was the principal producer after

the Belgian Congo. Northern Rhodesia, however, has suddenly entered the field, with a production of 11,428 cwt. of cobalt in 1934. This is an example of the kind of minor surprise that may occur in newly developed lands.

Copper.—Great Britain imports large quantities, for the production from domestic ores is now reduced to a few tons only. In 1928 the figures for external trade indicated a consumption in Great Britain of the order of, say, 150,000 tons, which was some 50,000 tons more than the total production of the Empire in the same year; but, since 1928, the output of copper in Canada and Northern Rhodesia has greatly increased. In each of these areas the ore raised in 1933 contained over 129,000 tons of the metal. Redistribution figures within the Empire show that, as a whole, the Empire now is nearly self-contained for copper, and with freedom of assembly on the Atlantic the normal requirements of Great Britain could be met from Canada and South Africa, with prospects in the near future of having a considerable surplus to spare.

Graphite.—It is not likely that any deposits in Great Britain could ever be developed to meet the full requirements of the country. The graphite imported in 1928 amounted to about 15,000 tons, which is not far from the maximum output of the Empire, Ceylon being the only large-scale producer. Artificial graphite could be made to meet some small needs, but isolation of Great Britain would make the shortage of graphite distinctly embarrassing. About one-quarter of the natural graphite now imported goes out again in the form of crucibles; but the retention of these would not meet our full war demands.

Iron.—In 1929 the output of pig-iron in Great Britain was over 7½ million tons, and that produced for steel-making was about half basic, half acid in quality. The output could be raised quickly to 10 million tons and this would require about 20 million tons of phosphoric ore, plus 10 million tons of acid hematite. The normal output of phosphoric ore can be increased to some extent if necessary; but it would be difficult to raise annually more than about 2 million tons of hematite within the country. During the War, iron-ore up to about 6 million tons annually had to be imported from foreign sources.

Lead.—Great Britain produced nearly 40,000 tons of lead in 1933 and could increase the output in an emergency to a small extent. The amount of pig-lead annually imported is, however, well over 250,000 tons, and "other sorts" of lead imported are in quantity approximately of the order of that exported. The margin could be partly covered by the output of Canada (about 150,000 tons), South West Africa (about 25,000 tons) and Newfoundland (over 30,000 tons). Further afield large producers are Burma (over 90,000 tons) and Australia (over 200,000 tons). Thus, with freedom of assembly, the Empire could rely on its own resources in lead.

Magnesite is not raised in Great Britain and could be replaced only partly by dolomite in steel-smelting. Canada and India might be able to raise over 30,000 tons each and Australia possibly another 10,000 tons in a year. These could thus supply ordinary requirements, which can be estimated at 30,000 to 40,000 tons annually.

Manganese-ore.—The amount of high-grade ore raised in Great Britain is negligible, but enough and

to spare is obtained from the Gold Coast, where the exports in both 1929 and 1930 exceeded 400,000 tons. The more distant source of India can produce annually nearly a million tons if necessary. The annual imports of ore before the recent depression amounted to over 200,000 tons, partly for home consumption and partly for meeting the export of ferro-manganese and spiegeleisen.

Mica is not produced in Great Britain, and its requirements are met by importation mainly from India; but considerable quantities, generally less suitable, are obtainable from Canada and South Africa. The annual requirement of Great Britain is usually near 1000 tons, and with an output of over 4000 tons in India, stocks to tide over an emergency might possibly be accumulated.

Molybdenum, which is of growing importance, is produced in small quantities in Australia. The principal foreign producers until recently have been the United States and Norway; but Mexico is now figuring as a prominent producer. The production of ferro-molybdenum is, however, increasing and considerable quantities of the ore or ready-made alloy are imported now by Great Britain and Russia. This is an instance of a mineral that requires watchful study to form an estimate of its possible use for war purposes.

Nickel is obtained entirely from Canada, either as pure metal or as matte for refining in Great Britain. The output of nickel in the world reached 55,000 tons in 1929; and of this total, 49,230 tons came from Canada and 4300 tons from New Caledonia. The rest of the world is practically dependent on these two sources.

Petroleum may to some extent be replaced in future by powdered coal, but it is obvious that efficiency of of transport will depend largely on obtaining supplies of liquid petroleum products, both as fuel and lubricants, in quantities well beyond those which will be produced in Great Britain for many years. Oil-shale can be used to meet a part of the demand, and the hydrogenation of coal may contribute supplies; but it is evident that Great Britain must rely largely on imported petroleum products. The only considerable Empire source on the Atlantic is Trinidad, with an annual output of 1⅓ million tons of crude oil. The total output of the Empire is over 3 million tons of crude, whilst the British concession in Persia adds 7 million tons more with reserves for expansion if necessary. Even with freedom of assembly maintained, the Empire could hardly be made self-supporting for oil, as a large part of the output will always be used for essential activities in the area of production.

Platinum is produced from the ores associated with nickel in Canada, and deposits in South Africa have recently attracted attention. Canada alone can supply the ordinary requirements of Great Britain.

Quicksilver.—Great Britain is entirely dependent on outside sources for quicksilver, as New Zealand is the only part of the Empire that produces any appreciable amount. The quantity of quicksilver imported annually (800,000 to 900,000 lb.) is many times the amount produced in the Empire.

Sulphur in pure form is not produced in Great Britain, and the amount raised as pyrites is quite small compared with that required for the heavy chemical industries. During ordinary years the country imports about 90,000 tons of sulphur, in

addition to over 300,000 tons of pyrites, the latter being mainly from Spain. The total quantity required could not be produced with certainty within the Empire, although Cyprus promises to be a substantial source of supply.

Tin.—Forty per cent. or so of the world's output of tin is produced within the British Empire, most of it from Malaya. Because of the established smelting facilities in Great Britain, large quantities of ore—80,000 to 90,000 tons—are imported annually, and the metal not consumed in the country is exported to the extent of 20,000 to 30,000 tons a year. Cornish ore could produce 2000 to 3000 tons annually, and ore from Nigeria some 10,000 tons; so probably the country is fairly safe for supplies of tin.

Tungsten.—Small quantities are raised locally, but the quantity of ore required for the manufacture of ferro-tungsten might amount to 4000 to 5000 tons in war-time. South Burma is the only large producer in the Empire, and might turn out one-third to one-half of that obtainable in China, where the output in 1929 was 8729 tons.

Zinc.—Small quantities of zinc-ore are raised in Great Britain, but the amount of spelter smelted reached 59,298 tons in 1929, practically all from imported ore, which in 1928 amounted to 167,080 tons. The actual requirements of Great Britain could be more than met from Newfoundland and Canadian ore, and considerable quantities are also obtainable from Northern Rhodesia. Further afield, Burma and Australia are the chief producers within the Empire.

From these notes it is apparent that so long as there is freedom to assemble materials from all parts of the Empire, Great Britain can rely on sufficient

supplies of essential minerals, except antimony, petroleum, quicksilver and sulphur. For most of them, too, supplies in sufficient quantities can be raised in areas around the Atlantic Ocean. Thus, the United States and the British Empire are nearly equal in the variety of their resources of war minerals, except that the States form one geographical unit of land on which the raw materials can be readily assembled, without chance of interruption, around the established industrial centres.

France, Germany and Italy

In tabular form (pp. 52-55) the domestic production and imports of each of these three countries are compared. From this table it will be seen that :—

(*a*) *France* is dependent mainly or wholly on foreign sources for antimony, chrome, copper, lead magnesite, manganese-ore, mica, nickel, petroleum, quicksilver, sulphur, tin and tungsten.

(*b*) *Germany* is dependent largely, in some cases wholly, on outside sources for aluminium-ore, antimony, chrome, copper, iron-ore, magnesite, manganese-ore, mica, nickel, petroleum, quicksilver, sulphur, tin and tungsten.

(*c*) *Italy* cannot possibly supply from her own resources her requirements under war conditions of chrome, coal, copper, iron-ore, manganese-ore, mica, nickel, petroleum, tin and tungsten.

Obviously, none of these Powers could maintain an army or a navy on a war footing if unable to draw supplies from foreign sources. They differ from one another to some extent in the lists of their shortcomings,

but these cannot and need not be equated, for many minerals that are absolutely essential are missing from all three countries. The mere fact, for example, that Italy has a surplus to spare of quicksilver and sulphur does not compensate for her lack of other mineral resources. Neither of them, if barred by the Mineral Sanction, could maintain war conditions against either of the other two that is free to draw supplies from outside; and even all three together, if they pooled their resources, would still be short of chrome, copper, magnesite, manganese, mica, nickel, petroleum, tin and tungsten. Italy could contribute a small amount of antimony to the pool, and Austria, if brought in, could supply the requisite amount of magnesite; but the want of liquid fuel would be serious until Germany is able to produce petroleum products by the hydrogenation on a large scale of brown coal, and that is quite unlikely in the near future. The adjustment of resources would be difficult, but no degree of co-operation would make up for the want of chrome, copper, manganese, mica, nickel, tin and tungsten.

COMPARATIVE STATEMENT OF MINERAL RESOURCES AND REQUIREMENTS

	France.	Germany.	Italy.
Aluminium.	The largest producer of bauxite in the world, with smelting capacity sufficient to meet the domestic requirements of aluminium.	Dependent on outside sources for bauxite. Has produced well over 30,000 tons of aluminium from imported bauxite, of which over 235,000 tons were imported in 1933.	Bauxite possibly sufficient for domestic requirements. Smelts 13,000 tons of aluminium.
Antimony.	Requires about twice as much as is produced in the country, but additional supplies are obtainable from Algeria.	No appreciable home production. About 3000 tons of regulus and scrap imported annually.	Production 300 to 400 tons, and about the same quantity imported under normal conditions. Production could be expanded to meet domestic requirements.
Chrome.	None raised in France, but abundance, with surplus to spare, obtainable in New Caledonia.	No domestic production. The chrome salts exported are made from ore imported.	No domestic production, and small external exchanges of ferro-chrome.
Coal.	Domestic production about 53 million tons, but 20 million tons of coal, plus 5 million to 6 million tons of coke, imported annually.	Production of about equal quantities of bituminous and brown coal, making an annual total near 300 million tons.	Quite small quantities produced, and about 12 million to 15 million tons imported annually.
Copper.	Only a few hundred tons produced from domestic ores. Quantities of the order of 150,000 tons imported annually.	About 30,000 tons produced from domestic ores. Rough copper and alloys imported up to about 150,000 tons, plus large quantities of ore of unknown copper content. Domestic ores could be developed to some but not to sufficient extent to meet requirements.	Very small quantities produced, and about 60,000 to 70,000 tons of metal imported annually. Home production could be increased to some extent.

Iron and Steel.	Ore available in abundance: annual output about 50 million tons, mostly phosphoric, suitable for basic steel. Pig-iron and ferro-alloys produced in 1929 exceeded 10 million tons. Relatively small external exchanges of iron and steel products.	With the loss of Lorraine domestic ore supplies are quite deficient. Imports amounted to 16,685,077 tons in 1929. Pig-iron and ferro-alloys produced in 1929 about 13 million tons. To this can be added now about 2 million tons from the Saar. Small external exchanges of iron and steel.	Production of ore only about 700,000 tons, and imports about 200,000 tons. Pig-iron and ferro-alloys annually produced, about half a million tons. About 150,000 tons imported, plus large quantities of scrap steel, plus other forms of steel of the order of 700,000 tons annually.
Lead.	Production from local ores about 9000 tons, to which may be added 20,000 tons from North Africa. Imports amount to 35,000 tons of ore and 100,000 tons of pig-lead annually.	Produces ore containing about 60,000 tons of lead; exports 30,000 to 40,000 tons. The metal smelted amounts to about 120,000 to 130,000 tons annually, large quantities of ore being imported.	Produces ore containing 30,000 tons of lead; exports about half the ore, and imports about 25,000 tons of pig-lead. The smelting output of the country is of the order of 20,000 to 25,000 tons annually.
Magnesite.	No home production. Imports considerable quantities of calcined magnesite.	Small home production. The mineral used is mainly from Austria, which produces abundance and sends large quantities to Germany, crude and calcined.	Produced about 17,000 tons in 1929 of crude. Imports 2000 to 3000 tons annually.
Manganese-ore.	Very small quantities produced. Ore imported annually about ¾ million tons.	Negligible home production apart from manganiferous iron-ore. Imports about 300,000 tons annually.	Production about 10,000 tons. Imports 90,000 to 100,000 tons annually.
Mica.	Entirely dependent on imports. Small quantities obtainable in Madagascar.	Entirely dependent on imports.	Entirely dependent on imports.

COMPARATIVE STATEMENT OF MINERAL RESOURCES AND REQUIREMENTS—*continued*

	France.	Germany.	Italy.
Nickel.	New Caledonia produces about 4000 tons annually, which is equivalent to about half the the usual requirement of France. Recovery of nickel from some complex domestic ores has been discontinued.	Mainly dependent on foreign sources. Imports of ore rose from 11,624 tons in 1930 to 33,968 tons in 1933, in addition to increased quantities of metal, 2609 tons in 1930 and 4407 tons in 1933.	Dependent on foreign sources. Imports about 1500 tons of metal annually.
Petroleum.	Crude oil to about 80,000 tons annually produced. Imports of motor spirit alone rose to 2 million tons, before the new law enforced the refining of oil in France. The crude imported in 1933 was nearly 2¾ million tons.	Produces about ¼ million tons of petroleum annually. Imports about the same amount of crude oil, plus about 2 million tons motor spirit and other petroleum products.	Produces 20,000 to 30,000 tons of petroleum, partly from shale. Imports about 100,000 tons of crude, 300,000 tons of motor spirit and large quantities of other petroleum products.
Quicksilver.	No home production. Requirements imported from Italy and Spain.	No home production.	The largest producer in the world, followed by the United States and Spain.
Sulphur.	Negligible domestic production. Produces about 180,000 tons of pyrites; imports 500,000 tons of pyrites, partly for its sulphur, as well as some 200,000 tons of crude and rock sulphur from Spain, Italy and the United States.	Small quantities recovered from gases. Imports about 50,000 to 70,000 tons of sulphur, and recovers large quantities from pyrites, which is produced up to about 200,000 tons, and imported to amounts over ¾ million tons.	Sicily, Japan and the United States are the largest producers of sulphur in the world; all three raise enough to spare some for export.

Tin.	Dependent on outside sources, including about 1000 tons produced in Indo-China annually. Practically no smelting in the country, and imports therefore are in the form of metallic tin.	Dependent on foreign sources. The Saxon ores have produced small quantities, but are now hardly worth working.	Dependent entirely on foreign sources.
Tungsten.	A few hundred tons of tin-tungsten concentrates are obtainable annually from Indo-China, but otherwise tungsten is not raised in French territory.	Dependent on foreign sources. Small quantities obtained in Saxony during the War. Imports 3000 to 4000 tons of ore annually.	Dependent on foreign sources. Imports small quantities for the smelting of ferro-tungsten.
Zinc.	Produces about 9000 tons of zinc from French ores. Larger quantities of ore raised in Algeria; small quantities in Morocco, and 15,000 to 20,000 tons in Indo-China. Imports of ore amount to about 250,000 tons a year, plus 40,000 to 50,000 tons of spelter. Metal up to about 20,000 tons exported.	Ore equivalent to 130,000 to 140,000 tons of metal raised annually before 1930. Imports spelter to about 130,000 tons, and ores 160,000 to 170,000 tons annually. Ores up to 180,000 tons and spelter up to about 40,000 tons, besides smaller quantities of other zinc products exported.	Ore with metal up to 80,000 tons annually raised before the recent depression. Spelter and other forms of zinc imported to amounts of about 15,000 tons. Most of the ore is exported, as the metal production in Italy is only of the order of 20,000 tons a year.

The Mineral Position of Japan

Very naturally one turns with special interest to Japan for another illustration of the way in which the Mineral Sanction might be tested; for Japan herself has recently advertised her own attitude to the rest of the Powers by a series of closely following consistent incidents; and the whole situation, as regards mineral supplies, is rapidly changing.

(1) On 27th March 1933, following the adverse unanimous vote of the League Assembly regarding Japan's action in Manchuria, the Japanese Government gave the required two years' notice of their intention to leave the League.

(2) On 17th April 1934 a spokesman of the Japanese Foreign Office indicated Japan's dominant rights in the Far East; and although this apparent indiscretion was afterwards explained, it naturally gave the impression that Japan was preparing the Powers for the declaration of an East-Asiatic version of something akin to the Monroe doctrine.

(3) At the end of December 1934 Japan denounced the Washington Naval Treaty of February 1922, and this takes effect at the end of 1936. Japan thus claims that her position and dignity requires naval parity with the United States and Great Britain, instead of the agreed ratio of 5 : 5 : 3.

(4) Consistent with this declaration, an article by Admiral Kichisaburo Nomura, published in the New York journal *Foreign Affairs* for January 1935 (pp. 196-203), indicated the necessity of revising at the same time the London Treaty of 1930 regarding the permitted scale of auxiliary vessels. Admiral Nomura referred to the unpopularity in Japan of the

Washington Treaty and instanced the feeling shown by the assassination of the two statesmen, Hamaguchi and Inukai. The Japanese representative at the Geneva discussions, Mr Matsuoka, referred similarly to the intense and unanimous feeling in Japan for a forward policy in Manchuria.

To Japan it seemed vitally necessary to reorganise Manchuria, for the growth of her mechanical industries is largely dependent on securing supplies of raw materials from North China. Accordingly, a new province was set up, linking the Chinese province of Jehol with Manchuria, as a separate kingdom under the name of " Manchukuo." Thus the other Powers, having taken no restrictive action consistent with the decision of the League Assembly, are now faced with a settled fact, and have before them the embarrassment of deciding whether they will recognise Manchukuo as an independent national unit.

Evidently Japan has by her aggressive action scored a definite diplomatic advantage ; for, Manchukuo being an independent state, Japan can disown legal responsibility for any indiscretions of the Manchukuo Government in enacting discriminatory commercial measures against other nations ; the establishment in Manchukuo at the end of 1934 of a petroleum monopoly is an example of these. But Japan would nevertheless intervene if another Power put pressure on Manchukuo, which beyond doubt is nothing more than a vassal state.

If, instead of forming sub-committees for further discussion, the members of the League and the United States had declared on 24th February 1933 that Japan would be supplied with no more of the minerals which she specially lacked, she would get no more

bauxite for her new industry of aluminium smelting ; no more lead, manganese-ore, mica, nickel, petroleum, platinum, quicksilver, or tin. If the other nations were ready to enforce this embargo, the new industries of Japan would have been threatened with paralysis, and the saner sections of the nation would have been able to control the rash enthusiasm of the militarists who are now urging the Japanese Government to certain destruction. Japan cannot at present provide from domestic sources more than a fraction of her requirements of these minerals, even under peace-time conditions.

The demand for naval parity with the United States has special significance, because it is obvious that Japan is in no possible danger of attack from any Naval Power so long as her responsibilities are not extended beyond her present areas of political influence. The establishment of dominance by force in Manchuria is obviously a move of strategic value, giving access if necessary : (*a*) to the Amur province of Siberia, and thus converting the eastern-most Russian provinces, with Vladivostok at their extremity, into an exposed salient ; and (*b*) to the areas in Shansi and Shensi that are known to be oil-bearing. The geographical situation in North-East Asia has thus been strategically altered since 1932 ; and other nations may naturally ask what it all means.

Large areas of the world have been barred against Japanese immigrants, who nevertheless do not show any strong tendency to colonise in Manchuria or even in Korea. For the rapidly increasing population at home, the development of mechanical industries in Japan itself seems to be the only visible form of relief. It is thus a vital necessity for Japan to secure mineral

raw materials from the near Chinese regions, and similarly, to be sure of obtaining good markets for her manufactured goods. For the first step in this direction the too slow pace of peaceful penetration in North China has now been suddenly accelerated by force. To form an idea of the nature of the next step, we must obtain an estimate of the kinds and quantities of minerals that are within reach of Japan.

The table on page 60 of this note shows her domestic production of a number of minerals for the three years, 1931-33. The same table shows the amounts of minerals imported during these years to supplement the home production. But it must be remembered that some of the minerals, that are now imported, could be partly replaced, if necessary, at a time of temporary emergency or at higher prices, by special development of low-grade or small deposits in Japan. Among these are possibly antimony, manganese and tin, which have been at times worked on a small scale. Nevertheless, the mineral resources of Japan itself are wholly insufficient to meet her industrial plans and apparent military ambitions. The only minerals that the country can produce in quantities sufficient for Japan's peace-time industrial requirements are chromium, coal, copper, graphite, sulphur and perhaps tin. Other minerals are produced in quantities too small, or far too small, for the present scale of industries.

But to the natural resources of Japan must be added those of Korea and now of Manchukuo. These between them can make some serious contributions of iron, either as ore or as pig-iron, magnesite (up to full requirements) and zinc. There are thus still obvious gaps in the list of essential minerals, and some of these can be partly filled up from South and

PRODUCTION OF PRINCIPAL MINERALS IN JAPAN COMPARED WITH IMPORTS

	Domestic Production.			Imports.		
	1931.	1932.	1933.	1931.	1932.	1933.
Aluminium—	(*a*)	(*a*)	(*a*)	...	...	...
Cryolite (tons)	...	...	...	279	393	215
Metal (tons)	...	...	...	2,744	4,718	3,549
				Metal and regulus.		
Antimony ore and regulus (tons)	(ore) 28	(ore) 66	(ore) 133	2,117	2,019	2,478
Chrome-ore (tons)	9,573	12,295	19,681	Chemicals only imported.		
Copper (tons)	74,650	70,741	67,942	152	291	13,117
Iron-ore (tons)	204,893	223,141	315,605	1,525,400	1,458,994	1,499,562
Pig-iron, including ferro-alloy (tons)	919,434	1,020,304	1,433,866	391,269	437,572	630,536
Steel ingots (tons)	1,853,383	2,360,404	3,145,660	2,196	13,024	39,121
Special steel (tons)	...	...	...	1,934	3,342	6,942
Scrap steel (tons)	...	...	...	290,931	550,251	996,963
Lead (tons)	4,006	6,313	6,917	52,741	54,466	65,547
Manganese-ore (tons)	12,646	25,828	42,847	8,839	42,141	66,228
Nickel ingots (tons)	...	...	...	765	1,711	3,139
Petroleum—						
Crude (*d*) (tons)	266,909	221,282	196,922	1,542,885	1,934,235	2,085,064
Motor spirit (tons)	211,699	268,034	(*a*)	286,600	317,800	334,000
Phosphate rock (tons)	20,814	18,461	34,193	405,509	550,583	692,572
Platinum (troy ounces)	275	266	206	32,229	11,075	33,137
Quicksilver (lb.)	7,725	5,256	17,807	580,800	751,300	813,638
Tin (tons)	1,577	1,557	1,538	3,152	3,382	3,433
Zinc spelter (tons)	10,000 (*e*)	10,000 (*e*)	10,000 (*e*)	20,170	20,574	26,651
Ore (tons)	(*a*)	(*a*)	(*a*)	24,507	34,983	37,216

(*a*) Information not yet available (Jan. 1935.) (*d*) Exclusive of fuel oil imported on Government account.
(*e*) Estimates published by *Metallgesellschaft*.

Central China, such as antimony, manganese, quicksilver and tungsten. South Central China now provides most of the antimony of the world, and other nations would be embarrassed if this area were barred to them. The tungsten deposits of China are also very large, but quite enough for the world's consumption can be obtained from South Burma, plus small deposits in other lands.

The imports and production, and therefore consumption, of most minerals in Japan have been rising in recent years in spite of the general financial depression. For example, in 1933 there was a notable increase in the imports of copper, graphite, ferro-alloys, pig-iron, special steels, steel-scrap, lead, manganese-ore, nickel and zinc. Japan has also been active in buying discarded merchant steamers in Europe, partly for utilisation ultimately as scrap steel.

Under war conditions Japan would require far larger quantities than those indicated by her imports plus home production, and many of the minerals can be obtained only from areas distant from the Chinese region, such as bauxite for aluminium smelting, lead, manganese-ore, mica, nickel, platinum and quicksilver. There is no doubt that the effective application of the Mineral Sanction to Japan, with Manchukuo and Korea (and even, if she had free access, to South China), would soon threaten her military and naval activities whatever may be her forethought in the accumulation of stocks.

It is not possible from the published figures to form a precise estimate of all the mineral dealings of Japan. There is, for example, no report of the output of aluminium ; yet it is evident, from the importation of cryolite and the corresponding reduction

in the imports of aluminium metal, that Japan is smelting the metal and is obtaining the necessary bauxite or aluminic oxide from foreign sources, recently from Malaya. There is similar evidence of the establishment of the smelting of zinc and ferro-manganese from imported ores.

Among the minerals that are essential to the development of Japanese transport power, petroleum is the one of which they are most in need. Failing either agreement with Russia, or dominance by force, the oil-fields of North Sakhalin cannot be relied on, and in any case may never be sufficient. The oil-shale fields of Manchuria produce a certain amount, but never will provide enough oil for the Navy. The Americans have not yet abdicated their responsibilities in the Philippines, but the (Hare-Hawes-Cutting) Act of March 1934 points in that direction, and the Filipinos ingenuously rely on the League of Nations for the preservation of their neutrality. However, oil prospecting in the Philippines has revealed more "shows" than productive wells. To seize the Dutch East Indies can hardly be regarded as an objective of the near future.

There thus remains Northern China to account partly for the Manchurian penetration towards Mongolia, for the most promising oil-fields are in Shensi on the southern border of Mongolia and western border of Shansi. In that area the prospects of obtaining a productive oil-field are distinctly favourable.

The policy of Japan is evidently dictated largely by the necessity for obtaining sufficient mineral products. In that she is well advised. The Mineral Sanction if applied in 1933 would have been a severe

check on her ambitions; it would still be a real menace, but the ineptitude of the other Powers, if continued, will give the military party in Japan further encouragement, and within a few years will alter her present position of danger from mineral shortage.

Russia

It is difficult to give precise estimates of the mineral resources of Russia, as the recent figures have not apparently been published uniformly and with mechanical precision; artificial stimulation in recent years has given rise to imports on a scale that may not be necessary in normal circumstances of settled development.

There is, however, some justification for assuming that Russia could be, if necessary, self-contained for supplies of aluminium, asbestos, chrome, coal, iron, lead, magnesite, manganese, platinum, petroleum, and zinc. But for supplies of antimony, copper, molybdenum, nickel, quicksilver, sulphur, tin and tungsten Russia seems to depend on imports, partly in the case of copper and sulphur, mainly or wholly for the others.

Russia has long been among the principal producers of petroleum and manganese-ores, but large tracts of the area covered by the U.S.S.R. are devoid of mineral deposits of value, and the assembly of those that are developed would require time long enough to be embarrassing during a time of sudden emergency.

PART III

MINERAL SUBSTANCES OF SPECIAL IMPORTANCE IN WAR

In this Part the minerals and metals of prominent value in the manufacture of munitions are described separately. Each is equally important in the sense that none can be dispensed with in the present mechanised conditions of armaments. Only to a very limited extent can two or three be partly replaced by substitutes, and then only with some loss of efficiency.

With the extension of mechanisation in the fighting forces, there has been a corresponding increase of mechanisation in essential civil activities. Consequently, the quantity available of each material becomes as important as the kind ; for what an army now wants in the field coincides qualitatively (though not quantitatively)—so far as basic raw materials are concerned—to a large extent with modern civil needs. These latter can be modified only to a certain degree during war. Transport facilities and communications, everyone knows, require large quantities of metals ; but fewer people are conscious of the importance of such lesser-known minerals as mica, magnesite and sulphur.

It is because war needs and civil needs so closely correspond qualitatively, that the best index to self-sufficiency is given by the figures for production and external trade. Generally speaking, an industrialised nation will not import minerals and metals that it

can produce. But this statement requires qualification when it is known that low-grade deposits, which are neglected in times of low prices, will be developed if necessary in times of stringency. There is, however, a limit even in this, because it takes time to open up mines and still more time to develop smelting facilities before the manufacture of efficient munitions is made possible. When, therefore, there is a wide difference between its production and import quantities, it is safe to assume that a country would be embarrassed if isolated by war or economic boycott. Both sides found this to be true during the War of 1914-18, but especially the Central Powers, which were partly blockaded. Even submarinism seriously affected the outside allied nations in their attempts to transport munitions from overseas to both Eastern and Western fronts.

Full knowledge of experience during the War would thus make any nation hesitate to go to war against the possibility of a Mineral Sanction. Each would realise that without a full supply—certain and uninterrupted—of all mineral raw materials, failure must follow within a short period ; for each mineral is essential : it is useless to be able to build a motor car if one cannot get a sparking plug.

In the accompanying notes the figures for 1928-30 are most frequently chosen as normally prosperous years which preceded the general industrial depression, with its artificial restriction of output. In some instances—Japan and Russia, for example—there are signs of later increased activity even up to the latest year reported.

Aluminium

On account of its high electric conductivity, aluminium was used to some extent in Germany to make up for the shortage of copper during the War. But the chief use of the metal, both pure and in alloys, is based on its low density. It is consequently in demand for the construction of air-ships, aeroplanes, machine guns of the air-cooled type and various portable forms of apparatus.

Although aluminium is the most abundant of the metals in the earth's crust, most of it occurs as silicates, from which it cannot be extracted without an expensive consumption of energy. The only ore used, therefore, is bauxite, in which aluminium occurs as a hydrated oxide. From this the oxide can be separated in the pure form by chemical treatment, and the metal is then obtained by reduction in the electric furnace. For the present, therefore, and probably for a long future, supplies of bauxite will determine a country's ability to produce aluminium in sufficient quantity.

France, Italy and the United States have abundance of bauxite to rely on. The amount obtainable in Northern Ireland is far too small to meet the needs of Great Britain, and the nearest large Empire source of supply is British Guiana, where the deposits have been opened up by a company which is subsidiary to the Aluminium Company of America. The Gold Coast also promises considerable supplies.

Russia and Japan are both relatively deficient in supplies of bauxite, but the information about Russia is incomplete. Russia is a large importer of the metal. Japan seems to have curtailed imports recently; but as there is a regular import of the

mineral cryolite, which is used as a flux, the smelting of aluminium has evidently been instituted in the country from imported bauxite.

On the whole, one cannot be sure that any of the principal Powers would be embarrassed for want of aluminium during a war in which ocean transport to Great Britain is free. Germany and Japan, however, would find it difficult to meet their needs unless they could draw supplies of bauxite from foreign sources.

Antimony

Antimony is consumed in additional quantities under war conditions because one of its many alloys is used for shrapnel bullets. Because of the antimony in it, type-metal, which is wanted during war as much as in peace-time, obtains its special property of expanding on solidifying from fusion : it thus produces a sharpness of character when cast into moulds.

The largest high-grade deposits known are in the provinces of Hunan and Hupeh, south-central China, where the mineral has been valued for ages as a source of vermilion pigment.

Of the total output of the world, amounting to about 30,000 tons, well over one-half now comes from China. During the War years, the output in this area was practically doubled. In 1913 the amount of antimony ore imported into Great Britain was 5503 tons, and in 1916 as much as 31,236 tons.

Bolivia, after China, was till recently the principal other producer, and in 1916 contributed 9905 tons to the total quantity of ore imported into Great Britain. But in 1930 the output of antimony in Mexico

exceeded that of Bolivia. Small quantities are produced in Canada and Australia; and among foreign countries, in France, Italy, Spain, and the United States. If the Chinese supplies ceased, the other countries might be to some extent embarrassed; but deposits which are now neglected might be developed to a greater extent on demand.

The American committee of specialists referred to above (p. 27) recommended the formation of a stock of 4000 tons in the United States as a war emergency reserve; that is, about half a year's normal consumption of antimony.

Cadmium

Cadmium is a relatively rare metal, and, being obtained in small quantities only, it has so far been little used in the industries. But it is worth consideration because some of its alloys offer possibilities of use in very special forms, and the metal might consequently become of important war value at any time in the near future. On account of the shortage of tin in Germany during the War, cadmium was used considerably for making solder metal and proved to be superior in strength to tin-lead solder.

Up to about fifteen years ago the world's production of the metal was obtained mainly from the United States and Silesia, but Australia, Canada, Mexico, Belgium, France and others have since then entered the field. Canada produced 773,976 lb. in 1929, Australia 445,907 lb. and the United States 3 million lb. Smaller quantities of the metal are now recovered as by-products in various countries, and soon (as seems likely from the progress of metallurgical research)

the alloys of cadmium may prove to be of value for very specialised uses.

Chrome

Various chemical substances and pigments are made of chrome salts, but the main use of the metal is for the manufacture of the alloy, ferro-chrome, which is used to give steels their special value for making armour-plate, armour-piercing projectiles, high-speed tool steel, and stainless steel. A considerable quantity of the chrome-iron-ore in its natural state is also used as a refractory material for lining furnaces. Chromium in various forms is thus an element of special importance for the manufacture of war munitions.

Within the British Empire, the largest producers are Southern Rhodesia, the Union of South Africa, and India. The outputs for these and the principal foreign producers during 1928 and 1929 are given in the accompanying table.

Principal Producers of Chrome-Ore

	1928.	1929.
	Tons.	Tons.
Southern Rhodesia . .	195,918	261,711
Union of South Africa .	31,255	62,964
India	45,455	49,565
Greece	20,622	23,832
Jugoslavia . . .	16,417	42,343
Russia (estimated) . .	28,000	28,000
Cuba	28,650	39,760
Japan	9,653	9,000
Turkey	11,662	14,840
New Caledonia . .	50,021	51,800

Figures such as those given in this table convey a very imperfect idea of the resources that can be drawn on if necessary. Some low-grade deposits are neglected for periods when prices are low, and are worked temporarily to meet new demands. For example, during the War years, Canada produced chrome-ore up to 33,000 tons in 1917. India produced small quantities at first, and then special efforts were made to develop the deposits of Baluchistan and Mysore, which between them produced 58,000 tons in 1918. The United States, which now reports only a few hundred tons annually, increased its output rapidly from 3300 tons in 1915 to 83,000 tons in 1918, and thereby nearly depleted the available reserves.

Copper

It was with " munitions " made mainly of copper that the people of the Bronze Age superseded those who could make weapons only from stone. And copper still is one of the most important of the metals required for peace-time industries as well as for the manufacture of armaments.

Substitutes may be used to replace copper in some of its customary uses, but not without loss of efficiency, and for some purposes it cannot be replaced at all. Some alloys like brass, bronze and cupro-nickel, contain proportions up to 80 per cent. of copper ; others, like German silver, monel metal and duralumin contain small proportions, but there is a wide range of varieties used in large quantities as essential war munitions, much of which is spent in a non-recoverable form.

A glance over the figures for annual production

shows how increasingly the metal has entered into the modern phase of mechanisation in industries. Round about the year 1800 the annual output of copper in the world was approximately 9000 tons; by the middle of the nineteenth century it had risen to 40,000, and by 1900 the annual production was half a million tons. From then on, its production rose year by year, even more rapidly than before, until 1929, when the output of the world reached 1,920,000 tons; thereafter the annual figures dropped to about a million tons, reflecting the general industrial depression which occurred.

These figures show how difficult it would be for an industrialised country now to exist without supplies of copper; for its replacement, even if technically possible, would require the use of some other metal in large quantities. The United States have hitherto supplied about half the world's output; but, during recent years, Canada has been increasing its production very rapidly. In 1913 its output was 34,365 tons; throughout the War years it rose to over 50,000 tons, and kept a little below this figure for seven years, when the output began to increase rapidly to 135,481 tons in 1930, and since has been generally near that figure. Northern Rhodesia, which formerly produced only a few hundred tons per annum, has now entered the field as a large producer, with the promise of providing still larger supplies in future. The output of Northern Rhodesia reached 129,423 tons in 1933. The Belgian Congo is also to be reckoned among the large sources of copper for the future, the output having reached 136,754 of smelted metal in 1930.

Taking 1929, which was the year of peak production, that is, before output was restricted by the

subsequent general depression, we get some idea of the principal producers up to then. The figures for 1929 are :—

United States	890,674 tons	
Chile	315,566 „	
Belgian Congo	134,828 „	(smelter output)
Canada	110,768 „	
Formosa	97,733 „	(ore output)
Mexico	85,187 „	
Japan	74,277 „	(smelter output)
Spain	63,000 „	
Peru	55,228 „	

Among the Great Powers, the United States and Japan can produce their own requirements of copper. The others are hopelessly deficient for the United Kingdom, France, and Italy, each produce only a few hundred tons per annum. If, however, the resources of Canada and South Africa around the Atlantic borders could be assembled, the United Kingdom could rely on sufficient copper from Empire sources. Germany might obtain within its own borders 20,000 to 30,000 tons. Russia might produce 50,000 tons, with some prospect of further expansion. But countries of this type require quantities well over 100,000 tons per annum to meet industrial and war needs.

Fluorspar

Fluorspar is known widely to the general public as an ornamental stone under the name of "blue john"; but it is on account of its far greater use as a flux in metallurgical industries that it is of importance in the manufacture of munitions. During the War, on

account mainly of its use in the increased production of basic steel, the output of fluorspar in the United States rose from 84,925 tons in 1914 to 235,551 tons in 1918, followed by a drop at the end of the War to 123,473 tons in 1919.

The following table shows the principal producers of fluorspar during the two years 1928 and 1929; that is, before the slump.

PRODUCTION OF FLUORSPAR

	1928.	1929.
	Tons.	Tons.
United Kingdom . .	46,862	41,762
France . . .	45,900	52,130
Germany—		
Bavaria . . .	47,785	49,995
Prussia . . .	36,775	37,121
Saxony . . .	16,163	18,199
Italy	4,449	5,649
United States . .	125,438	130,749
Korea	935	1,447

Great Britain and Germany export considerable quantities of fluorspar during normal years, whilst the United States is an importer in spite of its large domestic output.

GRAPHITE

Everyone knows of graphite under the names of plumbago and black-lead, a mineral which is used for the manufacture of so-called lead pencils, for polishing materials and as a lubricant. In the metallurgical industries, graphite is used mainly for the manufacture of crucibles. The graphite from Ceylon and Madagascar is the kind most highly

valued for this purpose; but during the War, supplies, generally of inferior quality, had to be drawn from other sources, and to a small extent artificial graphite was also used. There are fairly extensive deposits in the United States which are said to be unsuitable for crucible-making because of the fineness in texture of the flakes, but special efforts made during conditions of war shortage led to a considerable use of this graphite. With the restoration of normal conditions of external trade, however, foreign supplies were again resorted to by the American crucible-makers.

The peak years of world production occurred in the War years, 1916 and 1917, when the outputs were returned as in the accompanying table :—

PRODUCTION OF GRAPHITE IN TWO WAR YEARS

	1916.	1917.
	Tons.	Tons.
Canada	3,531	3,316
Ceylon	33,411	26,197
India	1,318	103
Austria	48,508	58,590
France	...	1,624
Germany	30,100	36,900
Italy	8,053	11,926
Spain	1,220	1,949
Madagascar	25,839	34,000
United States	7,221	12,137
Japan	1,129	1,308
Korea	7,738	8,698

A comparison of these figures with those for more recent years shows the extent of the special effort which was made in Europe and America to obtain sufficient supplies of graphite during the War.

PRODUCTION OF GRAPHITE IN 1928 AND 1929

	1928.	1929.
	Tons.	Tons.
Ceylon	14,347	12,739
Austria	23,843	24,897
Czechoslovakia . .	31,821	23,277
Germany . . .	17,188	21,012
Italy	6,919	7,352
Madagascar . . .	16,545	14,600
United States . . .	5,010	5,766
Japan	435	303
Korea	21,773	24,359

IRON AND STEEL

Although no highly industrialised country can carry on without supplies of ordinary iron and steel on a large scale, these alone are not of much use during war. Efficiency of mechanisation, as now understood, requires supplies also of various ferro-alloys; for example, those containing one or more, especially of chrome, cobalt, manganese, molybdenum, nickel, tungsten and vanadium.

Still, iron and steel are required in such large quantities that without a supply of domestic ores, and sufficient fuel for smelting them, no country could possibly stand alone. It would be quite impossible to accumulate sufficient stocks for any but a very short period of weeks, and any possibility of smuggling to defeat the Mineral Sanction would thus be unthinkable. Ores of iron occur in sufficient abundance to meet domestic requirements in the United States, Great Britain, France, Spain and Russia, but doubtfully in parts of China which are under the direct

control of Japan. Germany and Italy are among the important countries that would be embarrassed without supplies from outside. Germany, however, could produce from her own domestic ores over 2 million tons of iron annually, whilst Italy might find it difficult to raise for many years in succession much more than a quarter million tons.

During 1929, the output of iron-ore in the world reached a total of nearly 200 million tons, of which nearly 19 million tons were raised in the British Empire. The United States produced over 74 million, France about 50 million and Germany over 6 million tons. In that year Japan imported nearly 2 million tons of ore, about half of it from China, and produced only 175,000 tons within its own borders ; it is a large importer of iron and steel and is by no means self-contained for special forms.

There is a great variation in the proportion of iron contained in these ores. The rich hematites of India yield well over 60 per cent. of the metal, and ores of this sort occur there in enormous quantities. In the United States and Spain also the metal content of the ore is about 50 per cent. ; but the basic ores, largely raised in France and Germany, yield only about one-third of their weight as metal. Ores of about the same quality form the bulk of the ores raised in Britain, although the non-phosphoric hematite, used for acid steel, contains from about 50 to 60 per cent. of iron.

Ferro-alloys in new proportions, with new properties and new uses, are being developed every year. The adoption of these alloys is changing seriously the efficiency of machinery and structures of all sorts ; and, under war conditions, their effective use will

become a matter of vital importance to the country that can obtain the necessary accessory substances.

LEAD

Although there is far less lead than nickel in the accessible parts of the earth's crust, its ores are concentrated locally into rich lodes ; and, partly for this reason, it has been mined in large quantities at relatively low cost. The world's total output of the metal was well over 1½ million tons a year during 1928-30. Lead is one of those metals for which it would be impossible to find substitutes ; and consequently, under war conditions, uninterrupted access to sufficient supplies is of vital importance.

Before the War, Germany and Belgium imported large quantities of lead-ore from Australia, but the development of smelting, especially at Port Pirie in South Australia, materially altered the industrial equation. The principal producers of lead-ore are indicated by the figures given in the accompanying table.

PRODUCTION OF LEAD-ORE IN TERMS OF THE METAL

	1928.	1929.
	Tons.	Tons.
United Kingdom . .	14,829	18,608
South-West Africa .	26,300	25,500
Canada . . .	150,869	145,769
Burma . . .	101,600	102,100
Australia . . .	179,334	194,006
Germany . . .	56,673	59,509
Italy	31,208	30,051
Spain (smelter) . .	128,882	140,498
Mexico . . .	232,751	244,478
United States . .	559,958	578,567

Lead-ores are generally associated with those of zinc, and quite often yield valuable amounts of silver as a principal by-product.

Although countries in which smelting works are established export certain quantities of the metal, imports are on a definitely larger scale than exports in the case of Great Britain, France, Germany, Italy, and Japan. Before the War, Russia depended mainly on imports for the supply of lead, but mines have since been opened up, although figures for production are not published. The United States is the greatest producer, as well as the greatest consumer of lead, and consequently the amounts exported do not appreciably exceed those imported.

During the War years, the annual imports of metallic lead into Great Britain ranged about 200,000 tons at a cost of some £5,000,000, nearly half the quantity coming from Australia. The other main sources were Spain and the United States. Before the War, Great Britain exported over 30,000 tons of pig-lead every year ; but, on account of war demands, exports were curtailed to 2326 tons in 1917, and 59 tons in 1918, with a sudden rise after the Armistice to 16,010 tons in 1919.

Magnesite

The value of magnesite as a basic lining for steel and copper-smelting furnaces gives to the mineral considerable importance during war, although a quite large proportion of that produced is used for various other purposes in the Arts.

The figures given in the accompanying table show the principal producing countries during normal times :—

PRINCIPAL PRODUCERS OF MAGNESITE

	1928. Tons.	1929. Tons.
Canada—		
Crude	32,785	38,597
Burnt	11,781	16,794
India—		
Crude	24,406	23,497
Australia—		
Crude	10,786	9,115
Austria	305,000	430,000
Czechoslovakia	over 100,000	over 100,000
Greece	102,772	82,696
Italy	11,505	16,901
Russia	118,090	130,614
United States	113,571	167,554
Manchuria	Not reported	31,181

MANGANESE

Over 90 per cent. of the world's output of manganese-ore is used in, and is essential for, the manufacture of ordinary steel. The high-grade ores, that is, those with about 50 per cent. of the metal, are used in the blast-furnace for the manufacture of ferro-manganese. In addition to the use of ferro-manganese in ordinary steel-smelting, some of it is used for special steels containing high proportions of manganese, such steels having unusual qualities of hardness and toughness. Hadfield's manganese-steels were adopted in the War for the soldiers' so-called "tin" hats.

The experience of steel-makers in America show the importance of manganese. When Russian supplies of the ore were unobtainable, and sufficient shipping facilities could not be provided for Indian manganese-

ore, supplies were obtained to some extent from Brazil; but it was still found to be necessary also to resort to the low-grade ores of the United States. The output of ores containing 40 per cent. or over of manganese rose from 2635 tons in 1914 to 129,405 tons in 1917, and of leaner ores, below 35 per cent., the output rose from 98,265 tons in 1914 to 1,170,462 tons in 1918. The ordinary methods of steel-smelting had to be adapted accordingly. On the reopening of the ordinary trade routes, the American smelters naturally resorted to the use of high-grade ores, of which there are enormous reserves in Russia, India, the Gold Coast and Brazil.

The world's output of manganese-ore exceeded 3 million tons in 1929, that is, when the total output of steel passed 118 million tons.

The production of India has often approached a million tons per annum, and for many years a similar output was obtained in Russia. From the Gold Coast over 400,000 tons were exported in 1929, when the production in Brazil was near 300,000 tons.

All the chief highly industrialised countries are dependent on foreign sources for manganese-ore, Japan being able to draw considerable supplies from China and Malaya to supplement the domestic production of ore. On account of the embarrassment of the United States during the War, a committee of American mining specialists has since suggested the accumulation of stocks of high-grade ore to meet such possible conditions of temporary emergency. They recommended also investigation into the use of spiegeleisen (that is, a pig-iron with a relatively low percentage of manganese) to replace, if necessary, the richer ferro-manganese which is commonly used.

They wished an inventory to be made of domestic resources and the discouragement of the use of local ores when, in peace-time, foreign ores can be obtained.[1]

"The earth happens to be so made that none of the more important steel-making countries are able to supply their manganese requirements from within their borders, nor is any important manganese-producing country a large consumer of it."[2] India, with an annual output of about $\frac{3}{4}$ million tons of steel, is not yet an exception, as the domestic manganese-ore consumed is only about one per cent. of the annual production.

MICA

Mica of the best quality in sheets is mainly absorbed by the electric industries, but it is used also in various other ways where its special combination of qualities cannot be imitated by any natural or artificial substances: it can be split into the thinnest films, which are transparent to light, but relatively opaque to radiant heat rays; it is an imperfect conductor of electricity, resistant to acids and therefore to the weather; the folia are flexible and highly elastic, and therefore able to withstand sudden changes of temperature and shocks. Because of these properties, it has a wide range of usefulness in industries and cannot be replaced easily by substitutes.

The two principal varieties that are used are known as muscovite and phlogopite. India supplies the principal part of the muscovite of high quality;

[1] *International Control of Minerals*, New York, 1925, pp. 51-86.

[2] T. T. Read, *Elements of a National Mineral Policy*, New York, 1933, p. 80.

Canada and Madagascar mainly supply phlogopite. Because of the great range of quality and market value, it is difficult fairly to compare productions by weight; but many of the industrialised countries would be embarrassed without supplies from foreign sources; for example, France, Germany, Japan, and Italy which produce no mica; and, to a lesser extent, the United States, which produces insufficient amounts of high quality. Attempts to develop new sources were made during the War when normal market supplies were found to be insufficient.

Molybdenum

Molybdenum occurs in the form of the sulphide, molybdenite, a soft blue-black flaky mineral closely resembling graphite in appearance. This mineral, which was formerly used mainly for chemical purposes, and is still used in that way, was brought into prominence just previous to and during the War by the Germans in connection with the use of molybdenum as a special steel-alloy metal. Only in the late stages of the War and afterwards, however, was its value fully and widely appreciated by makers of special steels outside Germany.

In pre-War days, Australia was almost the only producer of molybdenite. During the War, Canada, Norway, and the United States figured among the producers. Of these producers, the United States commenced production seriously in 1915 and gradually increased its output, attaining a production of 83,748 cwt. in 1933, compared with 8149 cwt. in Norway, and 130 cwt. in Australia. Recent additions to production are those of French Morocco, Korea,

Peru and Mexico; and of these, Mexico promises to become important. This increase in the output of molybdenum is one of the more striking of the newer developments in the mineral industry. It is noteworthy that, whereas the production of vanadium has fallen heavily in recent years, molybdenum production has increased very substantially.

Nickel

Most people seem surprised to learn that nickel is twice as abundant as copper among the constituents of the earth's crust; and it is still more abundant than zinc, lead and tin. But the metal is widely disseminated as a rock constituent, and, unlike these other metals, is rarely concentrated in deposits which are rich enough to permit of profitable working.

Small quantities are obtained in many countries as by-products in the working of pyritic and other sulphide ores; but the bulk of the world's supplies comes from two areas, Sudbury in Canada and New Caledonia. In 1929, when production was most active, the output of Canada amounted to 49,230 tons, and that of New Caledonia to 5100 tons, out of a total for the world of 55,000 tons.

Recent researches have resulted in the production of various new alloys in which nickel is an essential constituent. The formation of special nickel-steels very definitely has extended the use of the metal in armament manufacture. Possibly under normal peace-time conditions about half of the nickel consumed is in the form of nickel-steels; but, through the increased demand for these in the War, over three-quarters of the available nickel was so consumed. As an

illustration of how the demand for nickel increases under war conditions, the trade figures for 1914 may be quoted. In that year Germany, for example, imported five times as much nickel from the United States as in any of the three preceding years, and most of it was secured during the first six months of the year. Up till then, and for sometime after the outbreak of war, a considerable quantity of the nickel-matte produced in Canada was sent to the United States to be refined ; and from there, so long as America was neutral, exports to Germany, partly direct, but mainly through the Scandinavian countries, could not be intercepted.

Figures for recent years show again an increasing import of nickel-ores and metal into Germany and Japan ; and some part of this increase is presumably due to the recent extension of armament manufacture. For other industrialised nations there has been no marked change in this direction of the trade in nickel.

Petroleum

Petroleum products in liquid forms are essential for transport facilities which require the use of internal combustion engines ; and it will be many years before the products of refining crude mineral oil will be displaced by powdered coal, alcohol, or by the products of the hydrogenation of coal.

The extended use of liquid fuel in the larger naval ships for steam-raising has given petroleum an additional importance, and any serious curtailment of supplies during war-time would hamper all three branches of the forces. For these reasons, France, Germany and Italy would be embarrassed if they

were cut off from foreign sources of supply ; for none of them can produce more than very small quantities of petroleum. Japan is better off, with small supplies of her own, some further oil from Sakhalin, and oil-shale in Manchuria ; but the total output of these sources is wholly insufficient to meet the needs of Japan even in peace-time. Her policy is evidently in the direction of prospecting in parts of China where indications of petroleum under favourable geological conditions have been found in recent years. Without the development of oil-fields under her control, Japan must remain dependent on imported oil, and would be paralysed under war conditions if these were cut off.

The United States is the principal producer of petroleum, but is also the largest consumer, and finds it convenient to import crude oil for refining during normal times. Russia is also a large producer, with surplus products for export.

The supplies of petroleum from British Empire fields are wholly insufficient, even for the requirements of Great Britain, and supplementary imports are obtained from Persia, the Dutch East Indies, Mexico, Russia and the United States.

The total production of crude oil passed 200 million tons in 1929, and in that year the United States contributed 136, Venezuela 19·5, Russia 13·4, Mexico 6·7, Persia 5·7, Dutch East Indies 5·2, and Roumania, 4·8 million tons.

Platinum

On account of its indifference to strong acid, its relative infusibility and malleability, platinum is of value for the manufacture of chemical apparatus.

But during the War, the pure metal was used in large quantities in our munition factories as a catalysing agent in making the highly concentrated sulphuric acid which was used for the manufacture of high explosives. Those countries that were compelled to manufacture nitrates from atmospheric nitrogen required platinum also in considerable quantities. When the Russian supplies failed during the War, substitutes with some difficulty were used.

The two principal regular producers for many years were Russia and Colombia in South America ; but there is a steady output annually recovered from the nickel-copper matte of Ontario and, in recent years, discoveries—still imperfectly developed—have been made in South Africa. Small quantities have for many years been obtained in New South Wales.

Quicksilver (Mercury)

Many countries produce small quantities of quicksilver, but the bulk of the world's requirements comes from Italy, Spain and the United States. The production recorded for Italy is mainly from the ancient mines of Idria in the province which was Austrian territory before the War and was transferred to Italy by the Treaty of Rapallo. The Spanish quicksilver is from the Government mines of Almaden, about 140 miles south-west of Madrid. California, Texas, Nevada and Oregon are the principal producers in the United States.

Fulminate of mercury is used as a detonator for high explosives, and gives the metal its principal importance during war-time ; but it is used in many other accessory ways that are indispensable during

war operations, whilst in normal times it is largely used for " amalgamation " in processes for the recovery of gold.

New Zealand is the only part of the British Empire that produces appreciable, but still quite small, amounts of quicksilver, the output being only a few thousand pounds per annum. In 1929, Italy produced $4\frac{1}{2}$ million pounds, Spain $5\frac{1}{2}$ million and the United States $1\frac{3}{4}$ million pounds. The old but imperfectly developed mines of south-central China may become of international importance. During the War, when high prices were paid for quicksilver, the output of China rose from less than 5000 to more than half a million pounds per annum, but fell off again to only 49,000 pounds by 1931.

Sulphur and Pyrites

In the native form, sulphur is produced in large quantities in the United States and in smaller quantities in Sicily and Japan. The other sources are negligible.

But the industrial countries of the world get most of the supplies that they consume from pyrites, mainly iron-pyrites which, when pure, contains 53 per cent. of sulphur. Copper-pyrites is generally accompanied by iron-pyrites and the two together may thus be worked for the copper and their combined content of sulphur. In the smelting of zinc and lead sulphides also sulphur may be recovered for the manufacture of sulphuric acid as a by-product. During the War, Germany resorted to the recovery of sulphur from sulphate of lime which occurs in the minerals anhydrite and gypsum.

Spain is about the largest producer of pyrites, and

the reserves proved in the southern province of Huelva are sufficient to last for many years, giving some supplies of copper as well as sulphur. Cyprus, though a small producer beside Spain, promises an increasing output of cupreous pyrites.

TIN

Mainly as a constituent of some indispensable alloys, tin is of importance for munitions' manufacture. Bronze, gun-metal, solders, fusible and soft-bearing metals, type-metal and pewter are among the alloys that are partly composed of tin. Only where tin is used for " containers " of various sorts could it be replaced—as was done during the War—by substitutes ; but the increasing use of tin-alloys will more than outweigh savings so effected.

The fact that most of the tin-ore now obtained is from alluvial deposits introduces a consideration of doubt about future supplies. However, complete reliance on original lodes—which are more expensive to work—will not occur for some years in areas like Malaya and Nigeria. But the known tin-bearing alluvial deposits are rapidly becoming depleted.

Cornwall is the only important source of tin in Great Britain ; the mines have been heavily worked but are still able to respond to a substantial rise in prices, and might perhaps be able to meet 10 per cent. of the needs of Great Britain if necessary. The remainder could be obtained from Nigeria and South Africa. Far larger quantities are imported from more distant fields, for the industry of tin-smelting has been maintained in Great Britain in spite of the relative depletion of the Cornish mines.

Nearly half of the world's supplies of tin are, or have been, obtained within the British Empire. In 1929 the total production in terms of metal was 192,000 tons, and of that, 90,000 tons came from parts of the British Empire, principally from Malaya ; by 1933, the world production had dropped to 91,000 tons, and of this 37,600 tons came from Empire sources.

The principal foreign importers of metallic tin are France (10,000 to 12,000 tons) ; Germany (14,000 to 17,000 tons) ; Italy (4000 to 5000 tons) ; Japan (4000 tons) ; Russia (4000 to 6000 tons) ; and the United States (about 80,000 tons). Germany has maintained smelting facilities on a considerable scale, producing annually 3000 to 4000 tons of metal, but only from imported ore.

TUNGSTEN

Pure tungsten in the form of filaments in electric lamps is familiar to most people ; but by far the largest part of the supplies of metal are consumed in the manufacture of " high-speed " tool steels and in some other alloys which are finding new uses.

British steel-makers before the War purchased their tungsten from Germany, where, up to then, it was made from ore mainly imported from Burma. Only a few months' stocks were available in Great Britain when the War cut out this supply of the metal, and special efforts were made at once to smelt the ore in England. Supplies in sufficient quantities were in this way provided at great expense from about the middle of 1915 to the end of the War.

Just before 1914, large alluvial deposits of the

principal ore of tungsten—wolfram—were found in the province of Hunan, China ; and, in addition to this new source, wolfram was obtained in fair quantities in South Burma and smaller quantities from various other countries. During the War the output of wolfram from Burma amounted to about 17,000 tons. Under the stimulus of uncontrolled war prices in America, the known deposits of tungsten were exploited in the United States nearly to depletion, and the country, which is normally the largest consumer, is thus dependent on foreign sources of supplies.

With the increased output from old deposits, and the rapid development of those newly discovered in China, the accumulation of stocks of wolfram at the end of the War put an end to mining operations for a few years. Towards the end of the last decade the production of China exceeded 8000 tons a year, but no other producing country turned out more than a few hundred tons, except Burma, which produced about 2000 to 2500 tons. All the Great Powers are importers of tungsten, or its ores, from outside sources, but small amounts are obtained in Japan and in Korea. So long as the alluvial deposits in south-central China hold out, there will not be any considerable quantities of ore developed in other lands.

The American resources of high-grade ore being largely depleted during the War, the committee of specialists referred to above (p. 27) pointed out that the ability of the United States " to meet increased demands (during war) will depend directly upon our ability to keep the seas open." [1]

[1] *International Control of Minerals*, 1925, p. 150.

Zinc

Among the countries that could meet their war-time demands for zinc from their own domestic ores are Italy, Japan, Germany and the United States. Russia and France are producers, but in quantities insufficient for their own normal needs ; both were formerly considerable importers, but France can supplement home production by ores from Algeria and French Indo-China, and Russia is developing her domestic ore deposits.

Small quantities of zinc-ore are raised in Great Britain. To meet industrial demands, large quantities of ore (about 150,000 tons) and similar quantities of spelter are imported annually ; but the total requirement of Great Britain is no more than the Empire can produce. The United States produce more than one-third of the world's supply—over 600,000 out of a total of $1\frac{3}{4}$ million tons. Within the British Empire, Australia, Canada, Newfoundland and Burma are the principal contributors to the annual output of ore sufficient for about 300,000 to 400,000 tons of metal. Before the War, Germany was a large producer of ore, and, with its great smelting facilities, dominated the zinc market ; but a large section of the area which included the Silesian deposits is now within the Polish border.

Although zinc forms an important and essential constituent of brass and many other alloys, none of the principal Powers is likely to be embarrassed for want of the metal. They all produce enough for actual war use ; for most of the zinc now consumed in the chief industrial countries is devoted to the so-called galvanising of iron sheets, and, naturally, this could be diverted to war use if necessary.

The deposits, in which zinc-ores occur, generally contain also ores of lead and other metals. Formerly there was a considerable waste in the dressing of these complex ores, but attention is being given to improved methods of separation previous to the smelting of concentrates. Electrolytic smelting is also gradually replacing the old-fashioned furnace operations, especially where the cost of labour is high. Canada and Tasmania are the largest producers of electrolytic zinc within the Empire; other large producers are the United States, France, Italy and Norway, all utilising relatively cheap water-power.

APPENDIX

EXTRACTS FROM ARTICLES X-XVI OF THE COVENANT OF THE LEAGUE OF NATIONS

Article X. (Guarantees against Aggression.)

The Members of the League undertake to respect and preserve as against external aggression the territorial integrity and existing political independence of all Members of the League. In case of any such aggression or in case of any threat or danger of such aggression the Council shall advise upon the means by which this obligation shall be fulfilled.

Article XI. (Action in case of war or danger of war.)

1. Any war or threat of war, whether immediately affecting any of the Members of the League or not, is hereby declared a matter of concern to the whole League. . . .

Article XII. (Settlement of Disputes.)

1. The Members of the League agree that, if there should arise between them any dispute likely to lead to a rupture, they will submit the matter either to arbitration or judicial settlement or to inquiry by the Council and they agree in no case to resort to war until three months after the award by the arbitrators or the judicial decision, or the report by the Council.

Article XIII. (Arbitration.)

1. The Members of the League agree that, whenever any dispute shall arise between them which they

recognise to be suitable for submission to arbitration or judicial settlement, and which cannot be satisfactorily settled by diplomacy, they will submit the whole subject-matter to arbitration or judicial settlement.

3. For the consideration of any such dispute, the Court to which the case is referred shall be the Permanent Court of International Justice. . . .

Article XV. (Disputes not submitted to Arbitration.)

1. If there should arise between Members of the League any dispute likely to lead to a rupture, which is not submitted to arbitration or judicial settlement in accordance with Article XIII, the Members of the League agree that they will submit the matter to the Council. . . .

6. If a report by the Council is unanimously agreed to by the members thereof other than the Representatives of one or more of the parties to the dispute, the Members of the League agree that they will not go to war with any party to the dispute which complies with the recommendations of the report.

9. The Council may in any case under this Article refer the dispute to the Assembly. . . .

Article XVI. (" Sanctions " of the League.)

1. Should any Member of the League resort to war in disregard of its covenants under Article XII, XIII, or XV, it shall *ipso facto* be deemed to have committed an act of war against all other Members of the League, which hereby undertake immediately to subject it to the severance of all trade or financial relations, the prohibition of all intercourse between their nationals and the nationals of the covenant-breaking State, and the prevention of all financial, commercial or

personal intercourse between the nationals of the covenant-breaking State and the nationals of any other State, whether a Member of the League or not.

2. It shall be the duty of the Council in such case to recommend to the several Governments concerned what effective military, naval or air force the Members of the League shall severally contribute to the armed forces to be used to protect the covenants of the League.

3. The Members of the League agree, further, that they will mutually support one another in the financial and economic measures which are taken under this Article, in order to minimise the loss and inconvenience resulting from the above measures, and that they will mutually support one another in resisting any special measures aimed at one of their number by the covenant-breaking State, and that they will take the necessary steps to afford passage through their territory to the forces of any of the Members of the League which are co-operating to protect the covenants of the League.

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